Highlights from ATLAS

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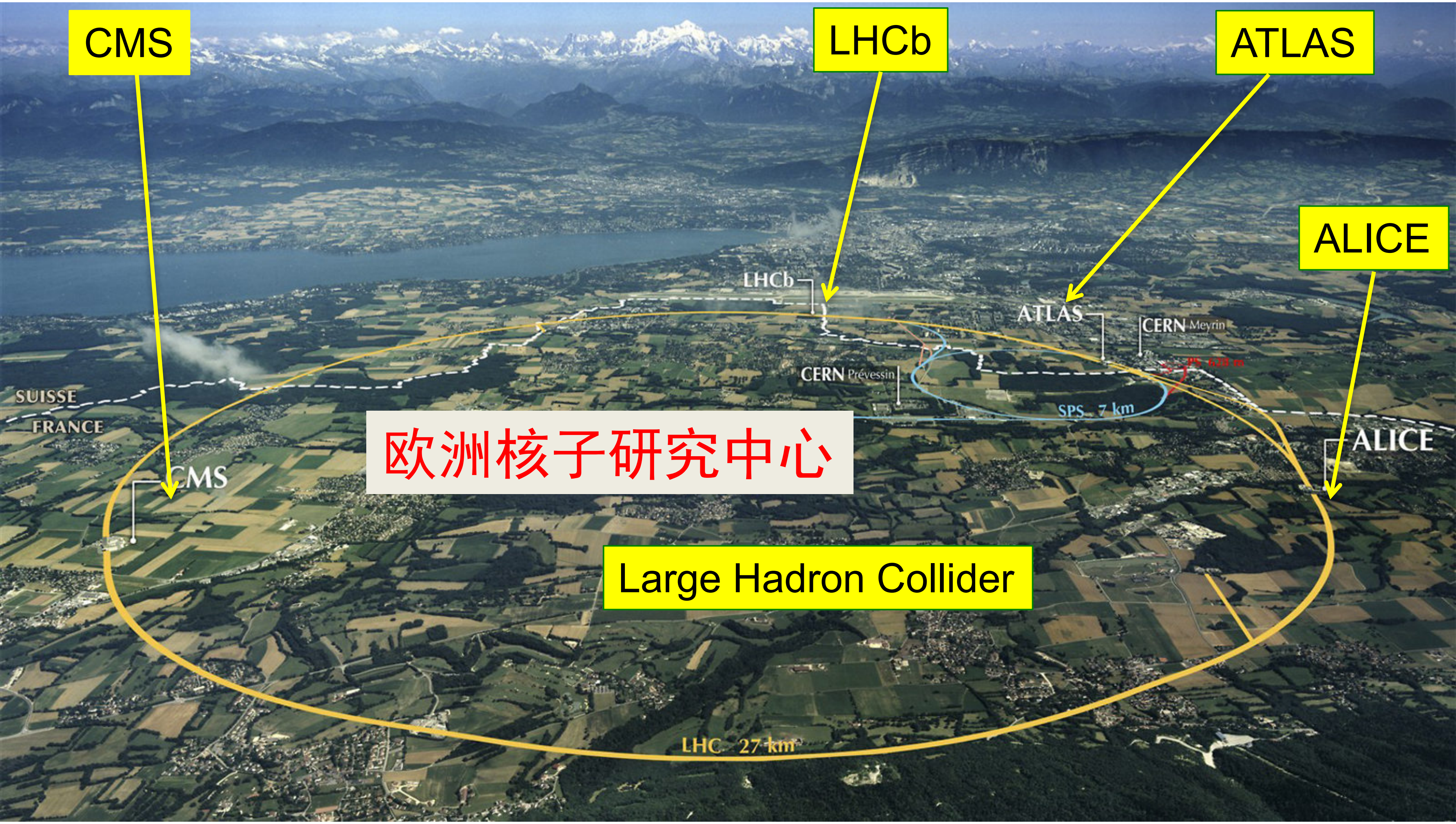
LHC（大型强子对撞机）


CMS
LHCb
ATLAS
ALICE
欧洲核子研究中心
Large Hadron Collider
LHCb
ATLAS
CERN Meyrin
CERN Prévessin
SUISSE
FRANCE
SPS 7 km
CMS
ALICE
LHC 27 km

LHC（大型强子对撞机）

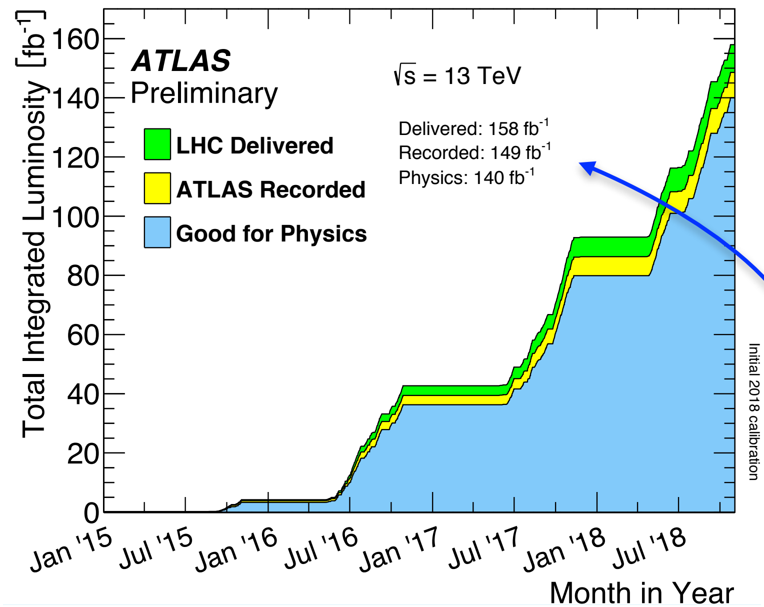
LHC已经运行近十年了！

一期：7 TeV (2010/2011)
8 TeV (2012)

二期：13 TeV (2015-2018)

2019-2020: 停机

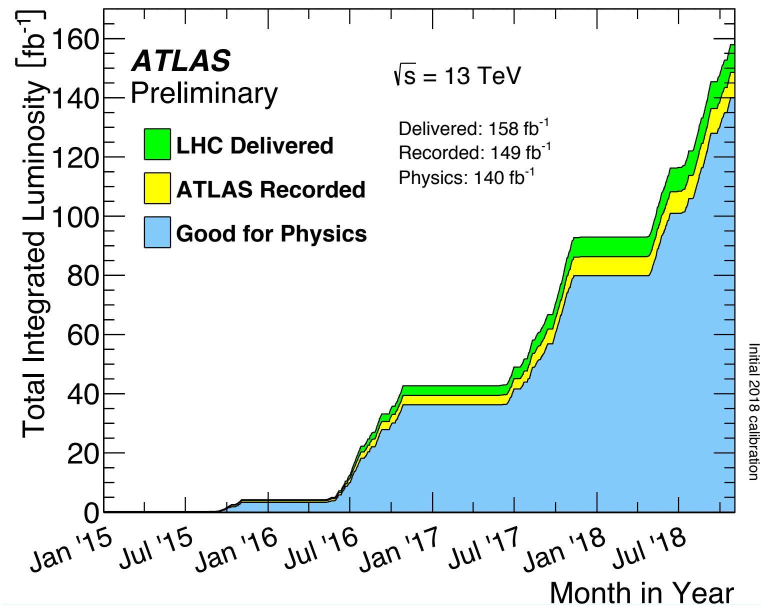
ATLAS数据采集@LHC二期

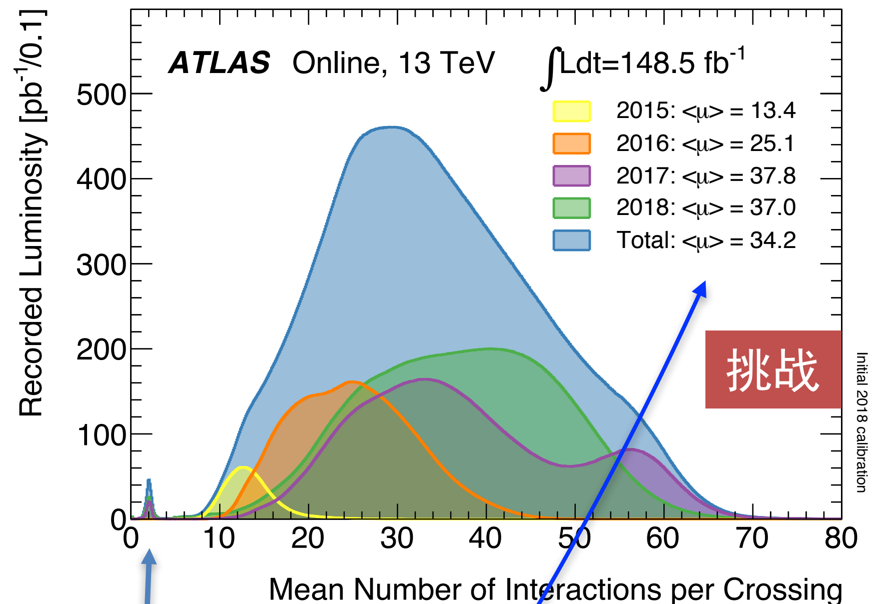


LHC二期运行顺利结束

- LHC delivered：158 fb^{-1}
- ATLAS采集：149 fb^{-1}，效率>94%
- 可用做物理分析：140 fb^{-1}

ATLAS数据采集@LHC二期





Low-mu data for precision measurement

LHC二期运行顺利结束

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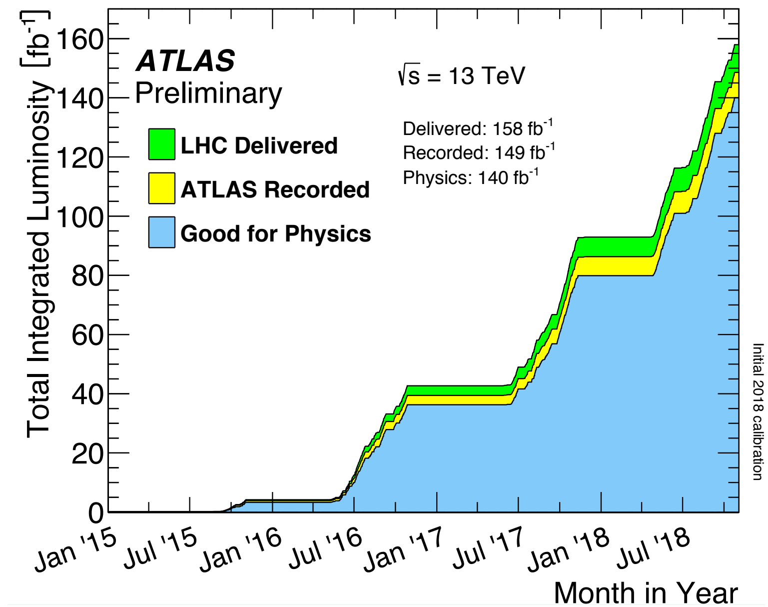
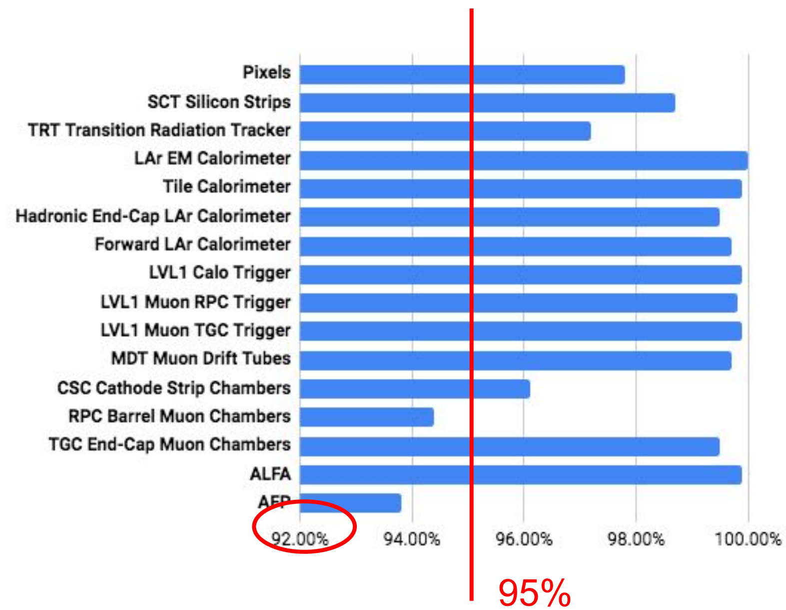
- 可用做物理分析：140 fb^{-1}

- 最高瞬时亮度 L = $2.1 \times 10^{34} cm^{-2} s^{-1}$
- 平均Pileup：~35

ATLAS数据采集@LHC二期



ATLAS pp data: April 25-October 24 2018										
Inner Tracker			Calorimeters		Muon Spectrometer				Magnets	
Pixel	SCT	TRT	LAr	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
99.8	99.8	100	99.7	100	99.8	99.7	100	100	100	99.6
Good for physics: 97.5% (60.1 fb^{-1})										



LHC二期运行顺利结束

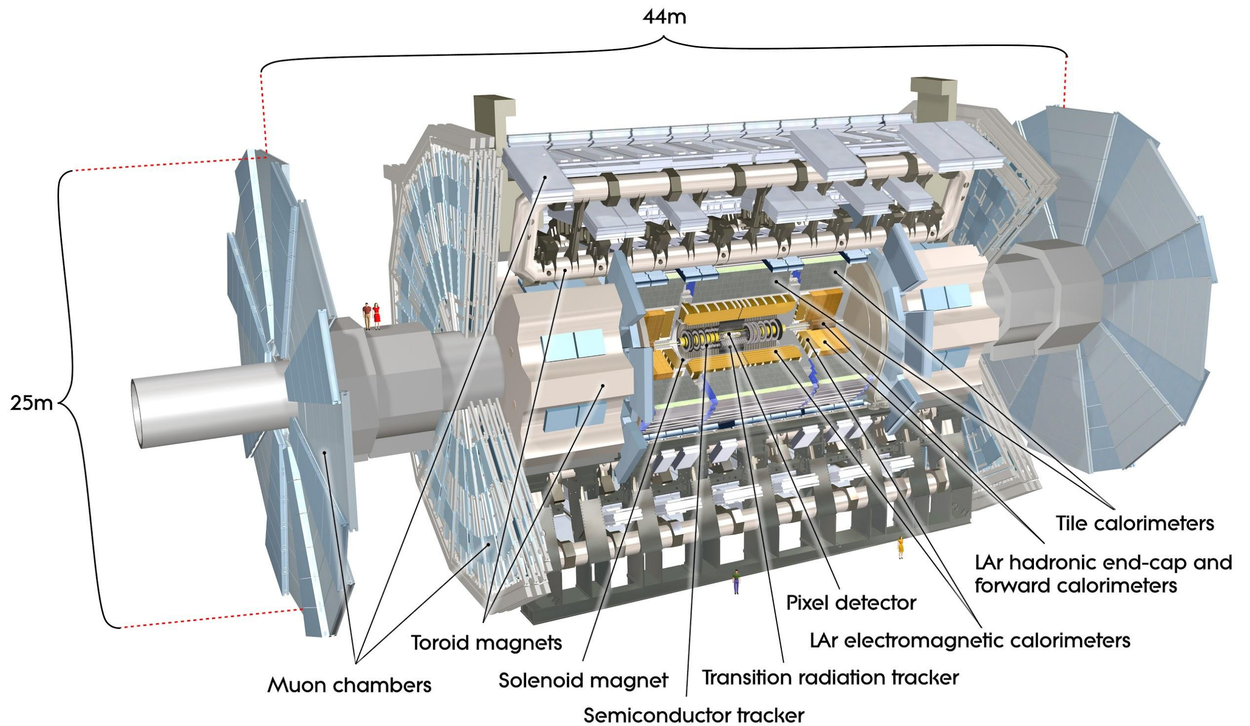
- LHC delivered：158 fb^{-1}
- ATLAS采集：149 fb^{-1}，效率>94%
- 可用做物理分析：140 fb^{-1}

- 最高瞬时亮度 L = $3x10^{24}cm^{-2}s^{-1}$
- 平均Pileup：~35
- 2018年取数：60 fb^{-1}
- 正常工作的探测器channel > 95%

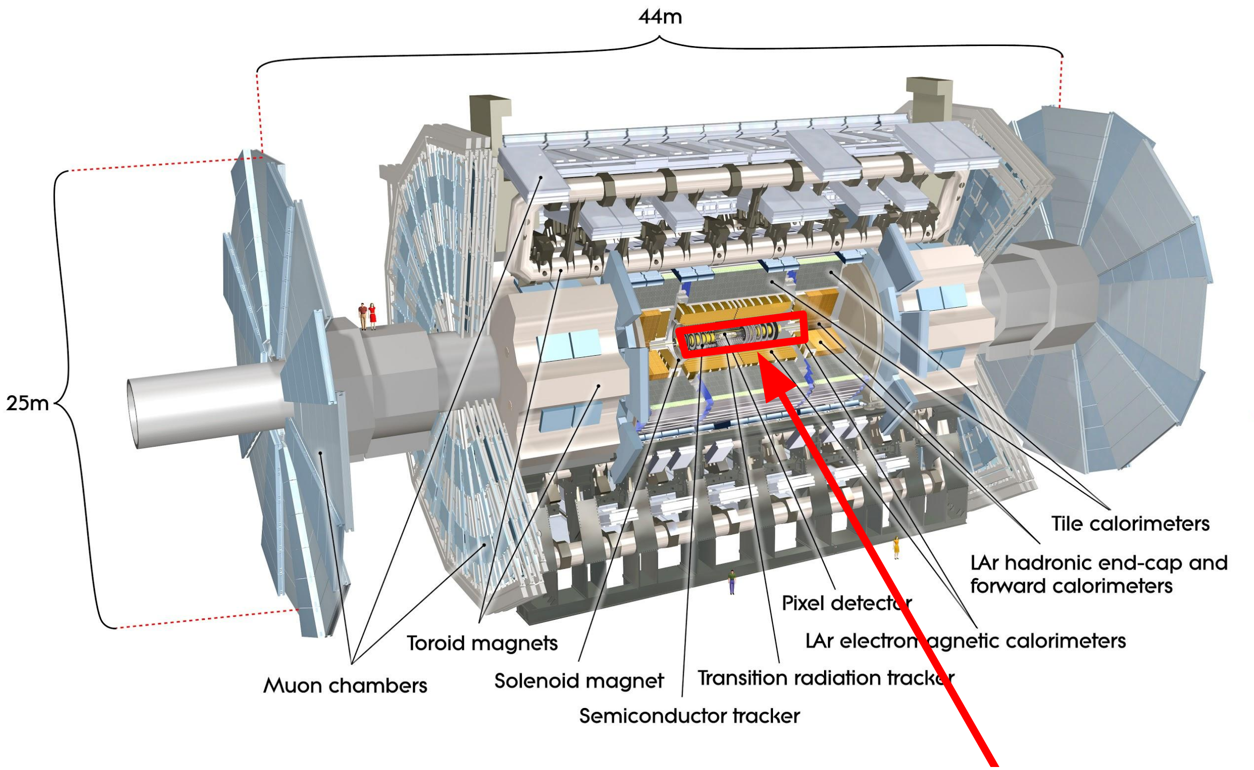
Data > 1 PB/day, 20 GB/s,
1.500.000 - 2.000.000 files / day

ATLAS 探测器 7000吨，长44米，高25米

ATLAS合作组：~3000人

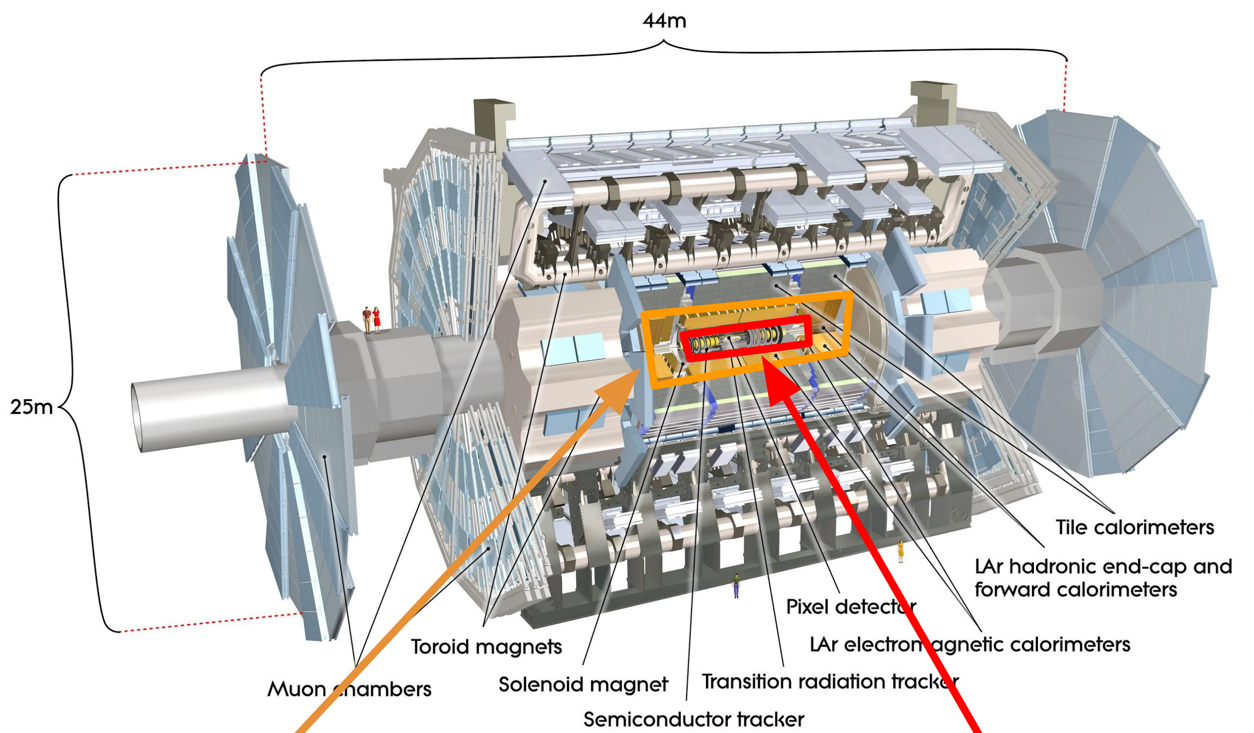


ATLAS 探测器 7000吨，长44米，高25米



内部径迹探测器（$|\eta|<2.5$）
2T Solenoid
Pixels, SCT and TRT

ATLAS 探测器 7000吨，长44米，高25米

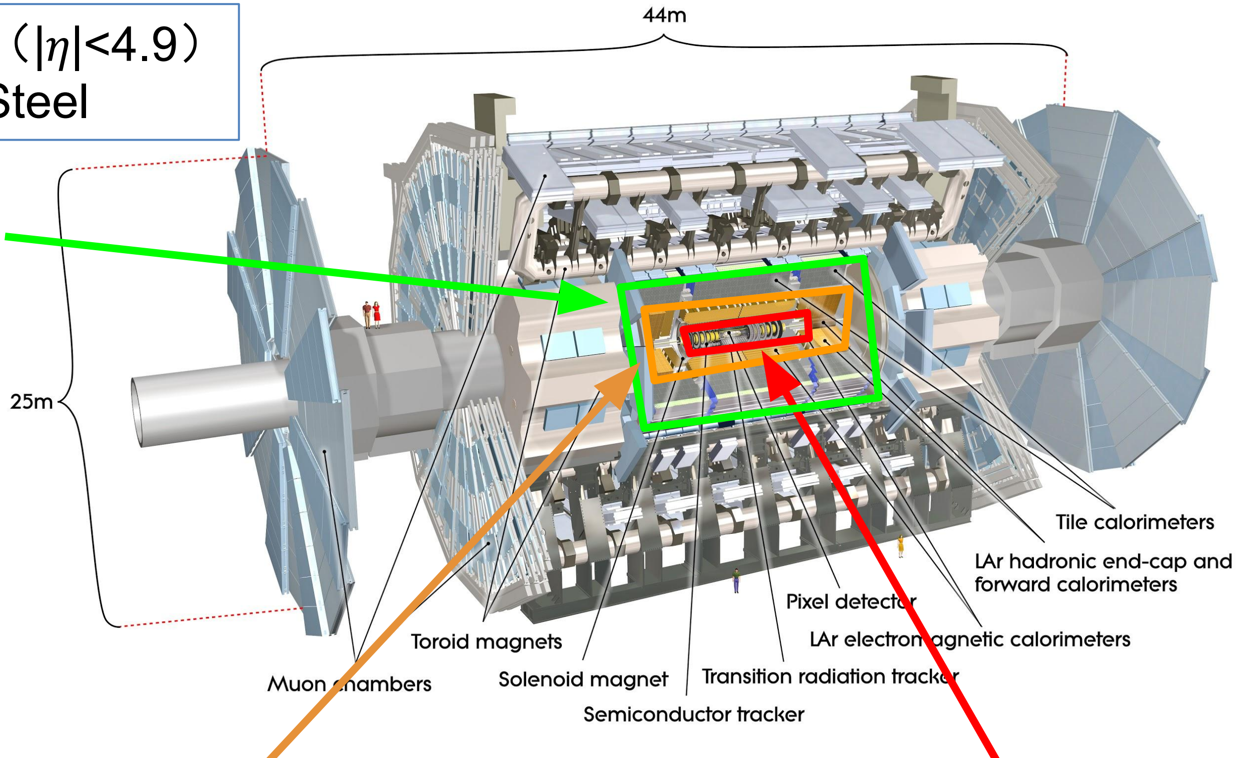


电磁量能器（$|\eta|<3.2$）
LAr/Pb

内部径迹探测器（$|\eta|<2.5$）
2T Solenoid
Pixels, SCT and TRT

ATLAS 探测器 7000吨，长44米，高25米

强子量能器（$|\eta|<4.9$）
Scintillator/Steel



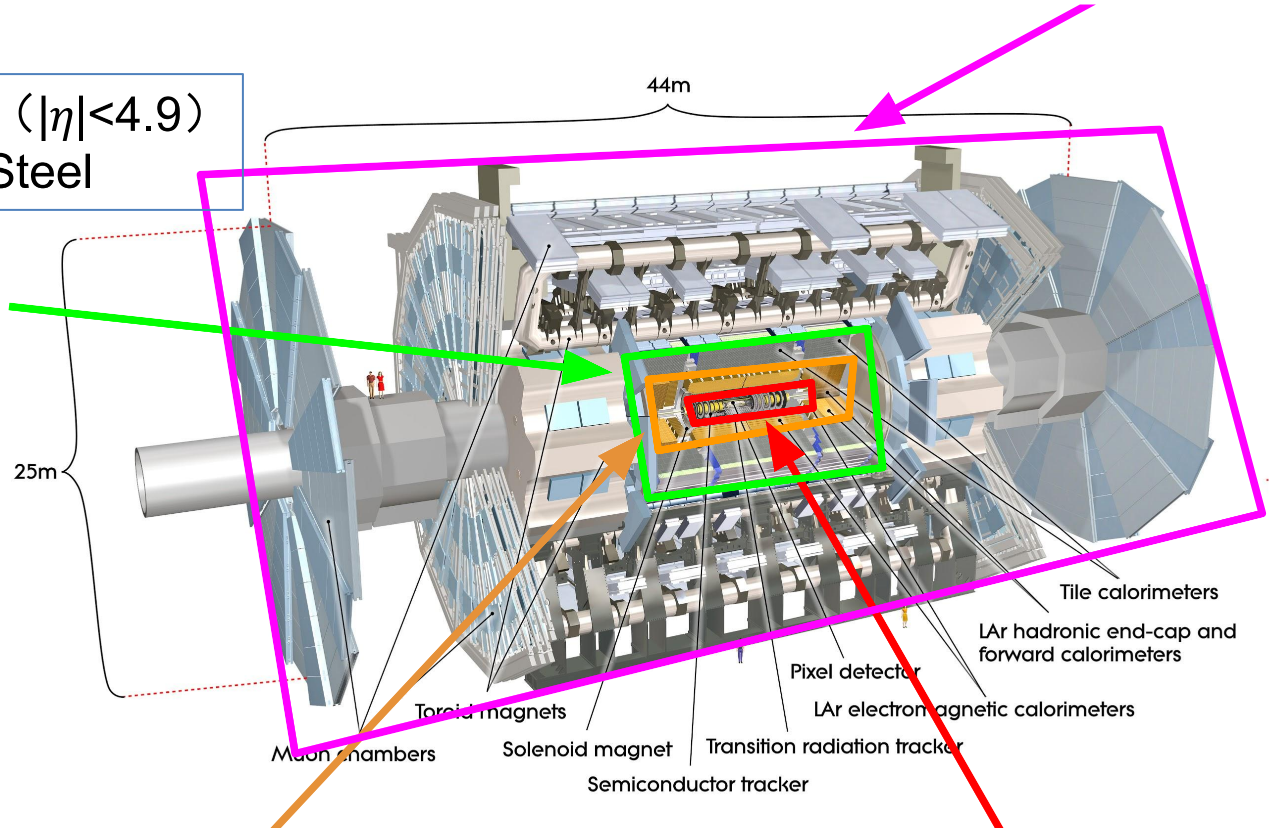
电磁量能器（$|\eta|<3.2$）
LAr/Pb

内部径迹探测器（$|\eta|<2.5$）
2T Solenoid
Pixels, SCT and TRT

ATLAS 探测器 7000吨，长44米，高25米

缪子谱仪（$|\eta|$<2.7）

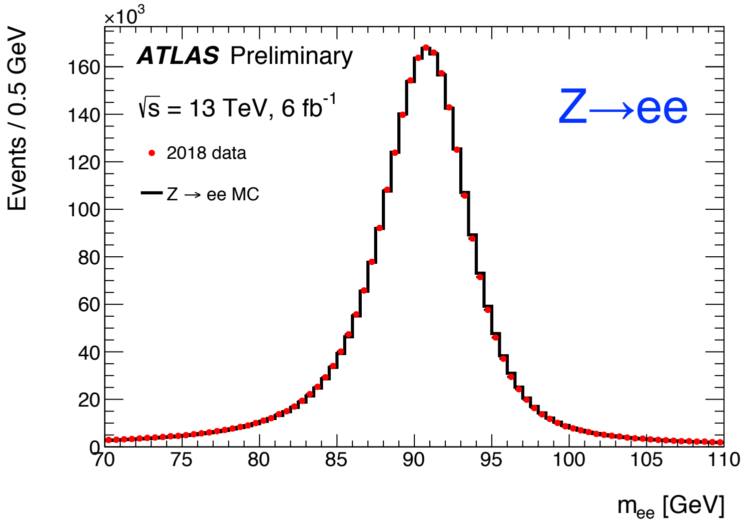
强子量能器（$|\eta|$<4.9）
Scintillator/Steel

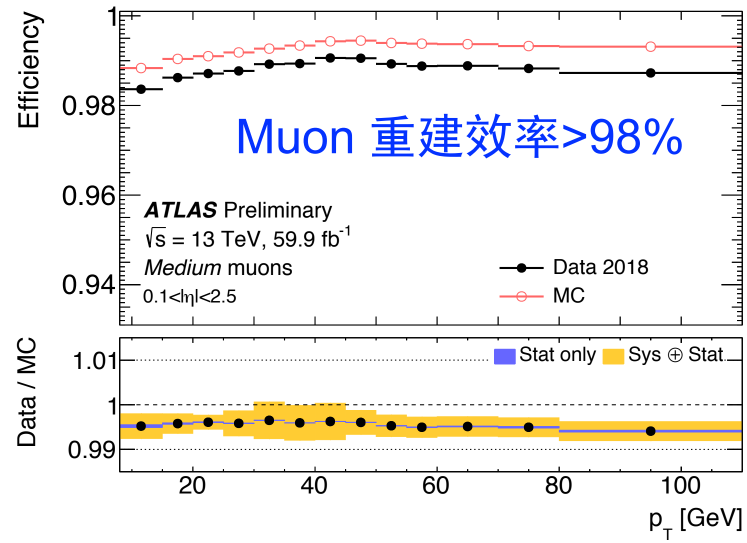


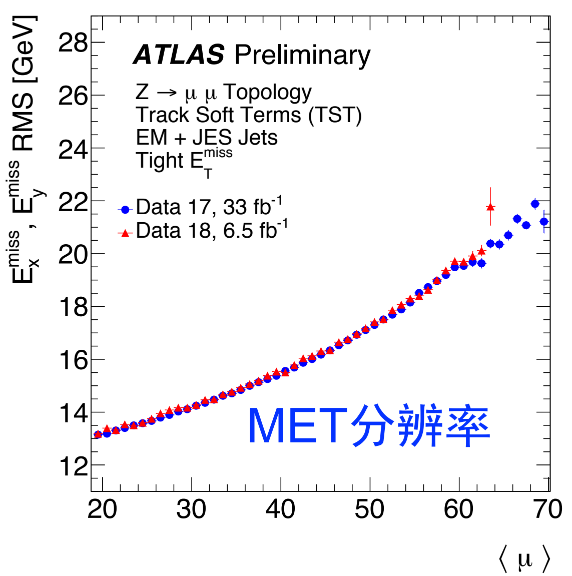
电磁量能器（$|\eta|$<3.2）
LAr/Pb

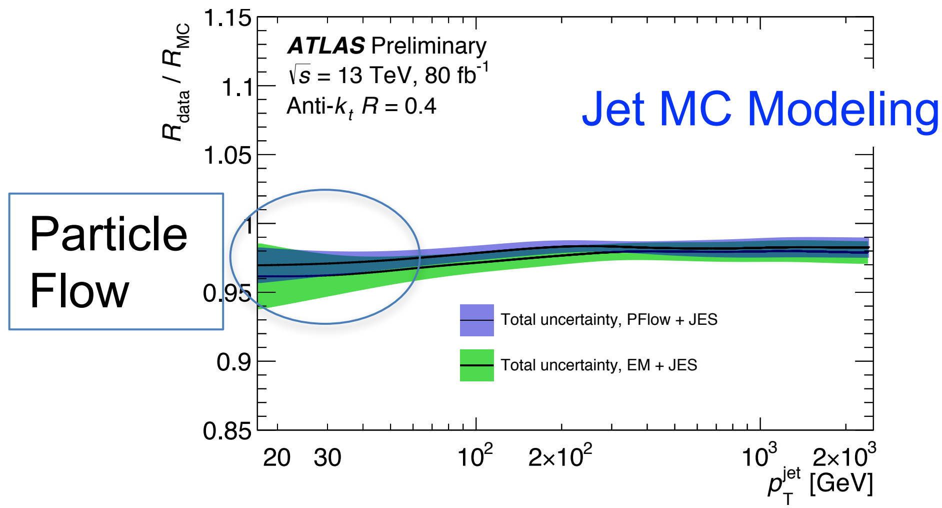
内部径迹探测器（$|\eta|$<2.5）
2T Solenoid
Pixels, SCT and TRT

物理objects的重建和测量





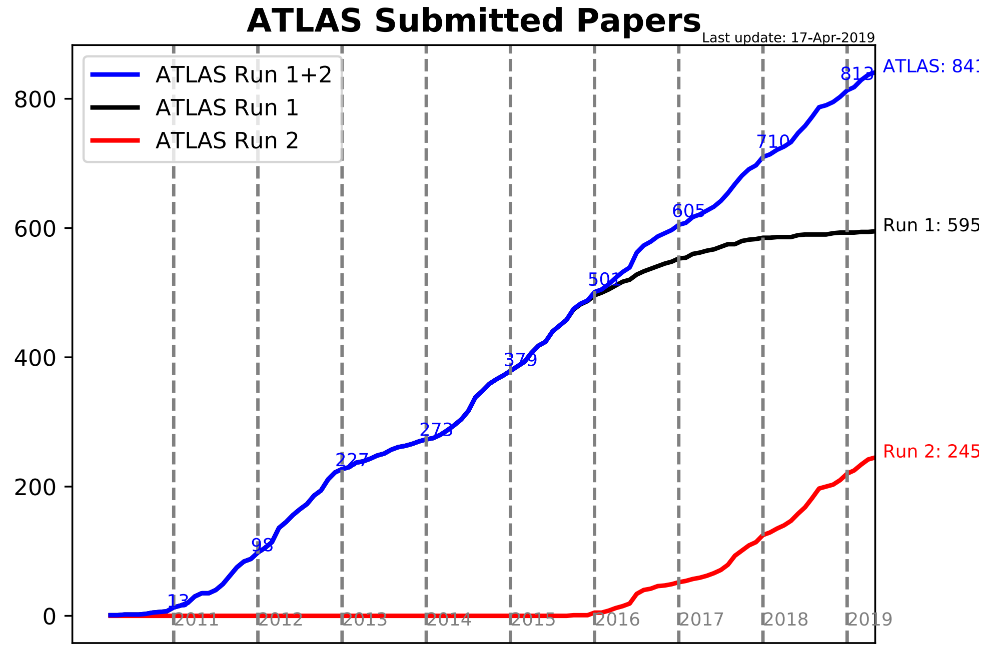




Highlights

到目前为止，ATLAS提交文章840篇

Only can cover some highlights from recent ATLAS results with personal bias



标准模型测量

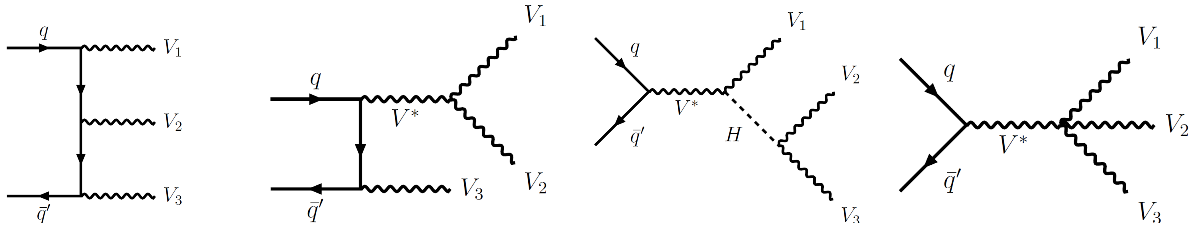
Evidence of VVV

arXiv:1903.10415

3个有质量的规范玻色子产生的迹象

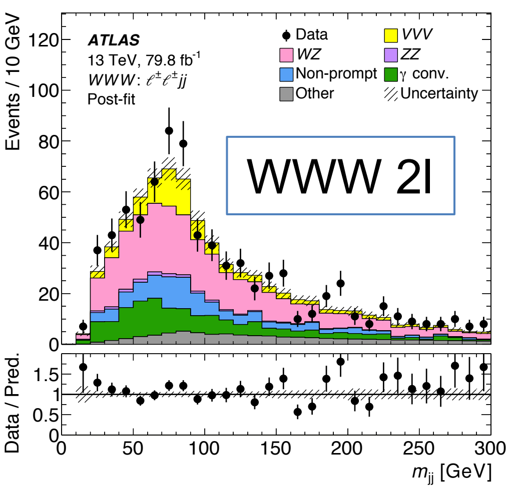
标准模型中的稀有过程

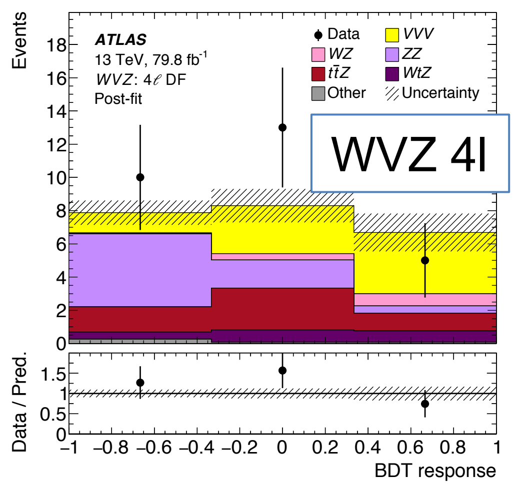
13 TeV, 80 fb-1

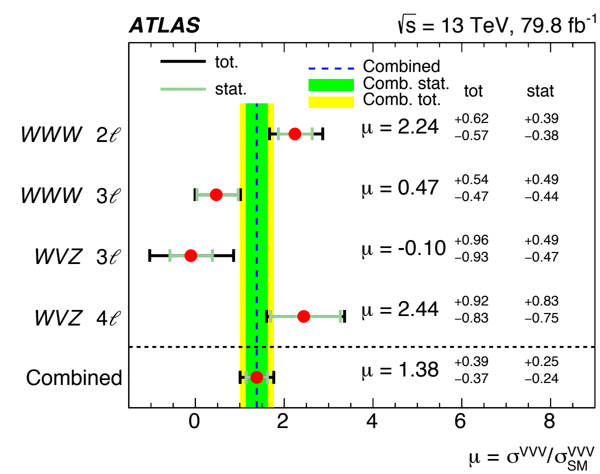


W±W±W∓： two same-sign leptons with at least two jets; three leptons

W±W∓Z and W±Z Z: three or four leptons



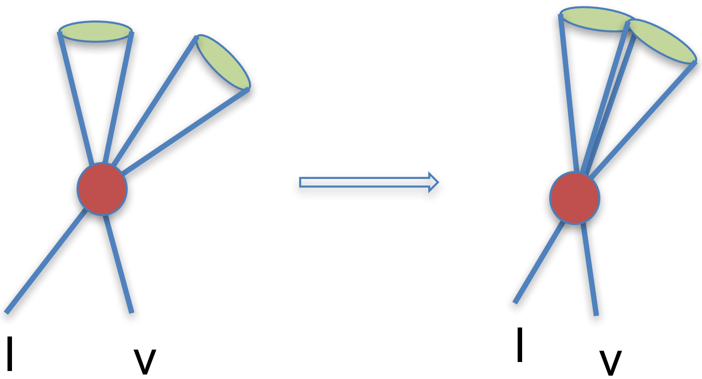




Obs: 4.0 σ; Exp: 3.1 σ

Jet Substructure 测量 arXiv:1903.02942

13 TeV, 33 fb-1



低质量　　高质量

喷注的两点、三点关联函数：

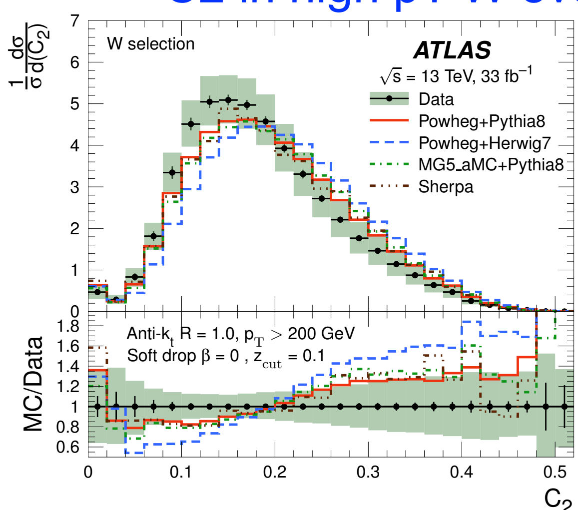
$$e_2^{(\beta)} = \frac{1}{p_{TJ}^2} \sum_{1 \le i < j \le n_J} p_{Ti} p_{Tj} R_{ij}^{\beta} \,,$$

$$e_3^{(\beta)} = \frac{1}{p_{TJ}^3} \sum_{1 \le i < j < k \le n_J} p_{Ti} p_{Tj} p_{Tk} R_{ij}^{\beta} R_{ik}^{\beta} R_{jk}^{\beta} \,,$$

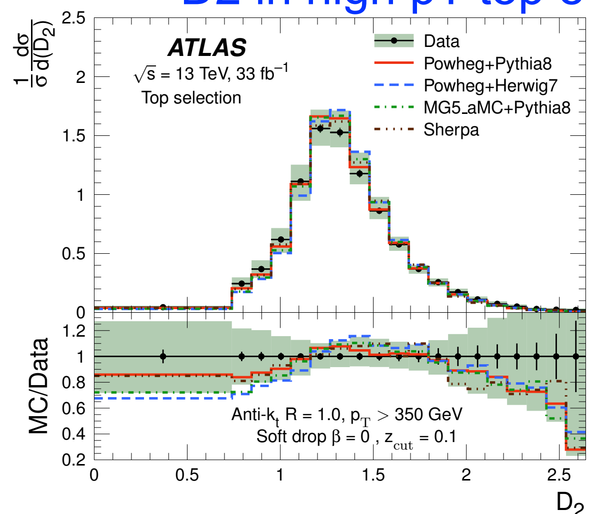
$$C_2 = \frac{e_3}{(e_2)^2},$$

$$D_2 = \frac{e_3}{(e_2)^3}.$$

C2 in high pT W events



D2 in high pT top events



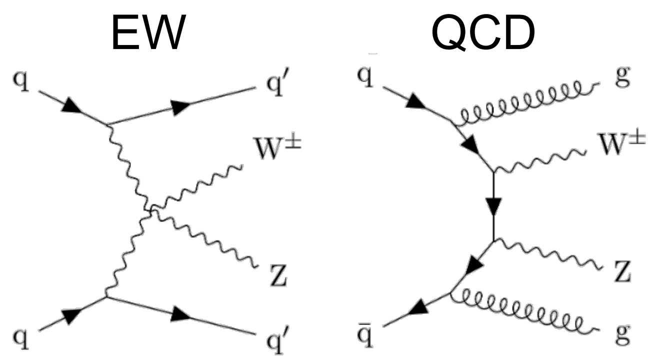
文章中还有很多其他的变量测量

VBS WZ

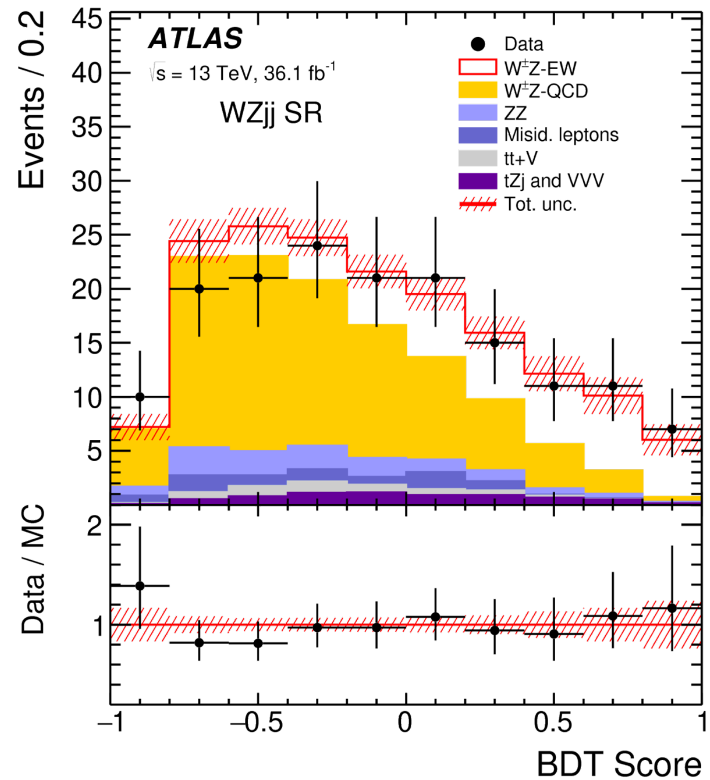
arXiv:1812.09740

13 TeV, 36 fb-1

Sensitive to quartic gauge couplings



- 判选：要求正好三个轻子 (e/mu)
- 使用BDT方法，15个变量
  (关于 vector bosons, leptons and jet kinematics)



Obs. (exp.) significance: 5.3 (3.2) σ

Still statistics limited

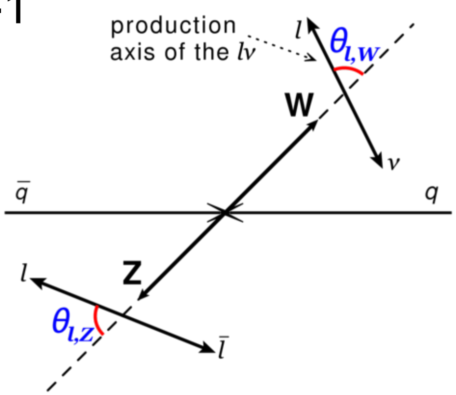
Fiducial XS. $\sigma_{WZjj-\text{EW}} = 0.57\ ^{+0.14}_{-0.13}\,(\text{stat.})\ ^{+0.07}_{-0.06}\,(\text{syst.})\ \text{fb}$

SM精确测量

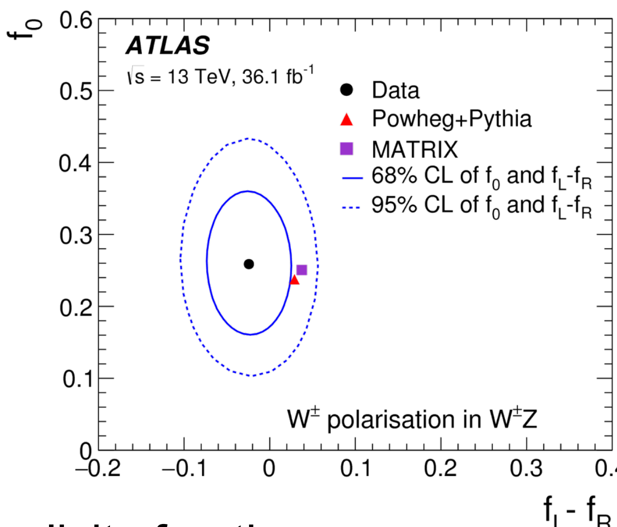
WZ的极化

arXiv:1902.05759

13 TeV, 36 fb-1



W/Z的质心系



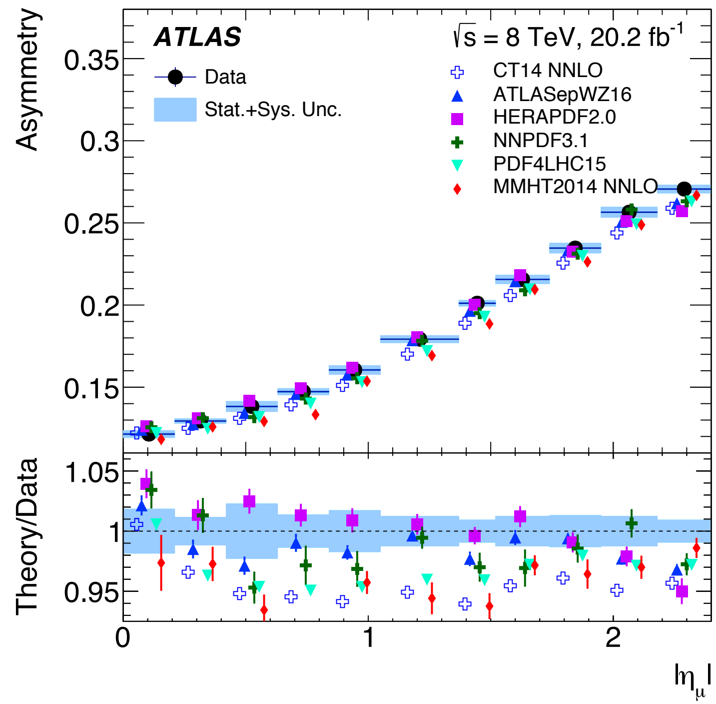
f：helicity fraction

MATRIX：NNLO

arXiv:1904.05631

W产生的电荷不对称性

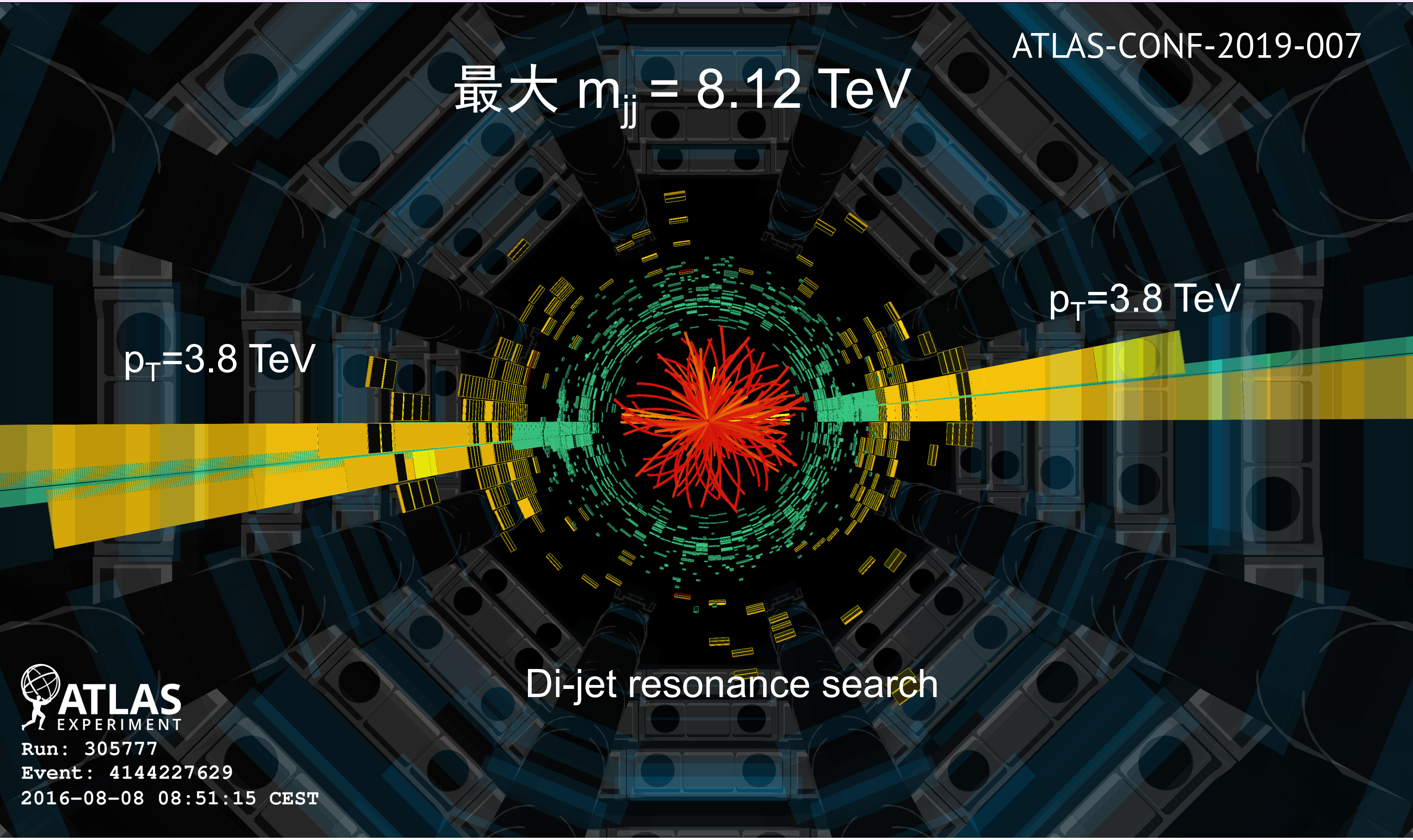
PDF



$$A_\mu = \frac{d\sigma_{W_{\mu^+}}/d\eta_\mu - d\sigma_{W_{\mu^-}}/d\eta_\mu}{d\sigma_{W_{\mu^+}}/d\eta_\mu + d\sigma_{W_{\mu^-}}/d\eta_\mu} .$$

8 TeV, 20 fb-1

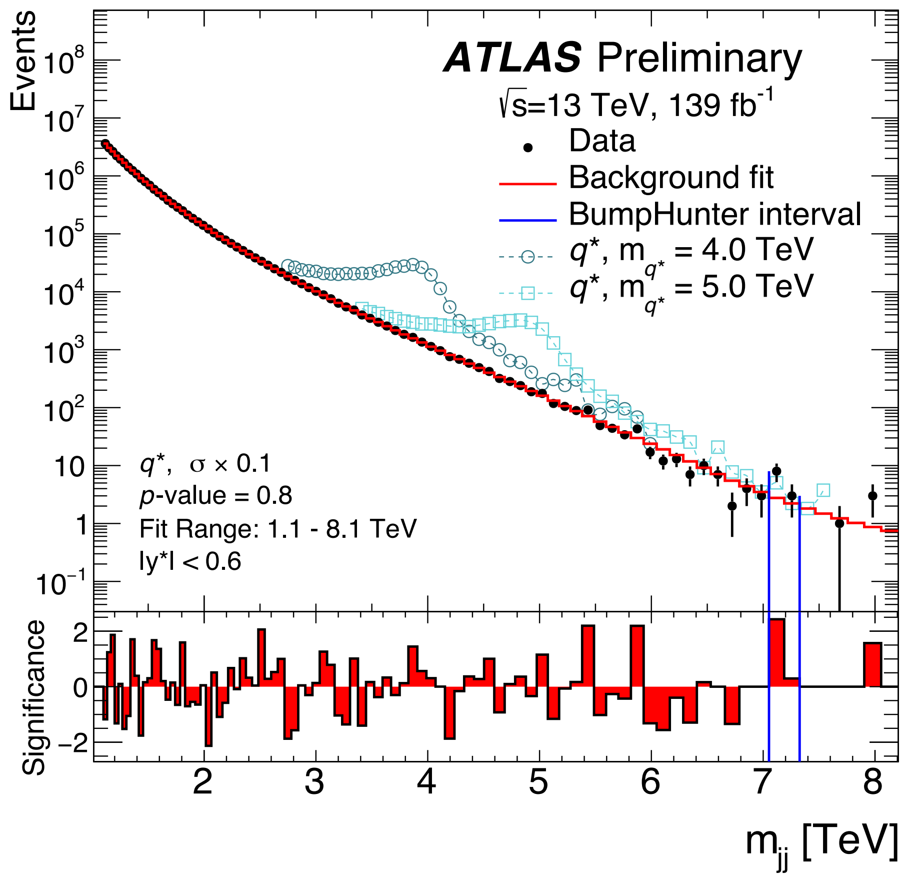
新物理的寻找

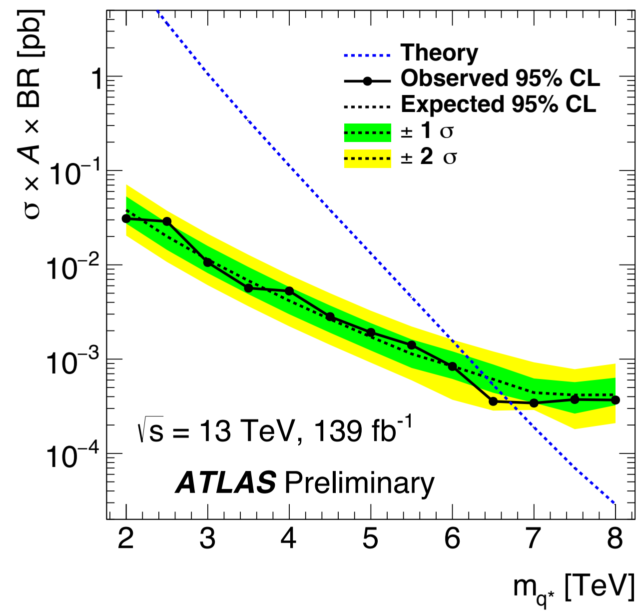

ATLAS-CONF-2019-007
最大 m_{jj} = 8.12 TeV
p_T=3.8 TeV
p_T=3.8 TeV
Di-jet resonance search
ATLAS EXPERIMENT
Run: 305777
Event: 4144227629
2016-08-08 08:51:15 CEST

X→di-jet 末态

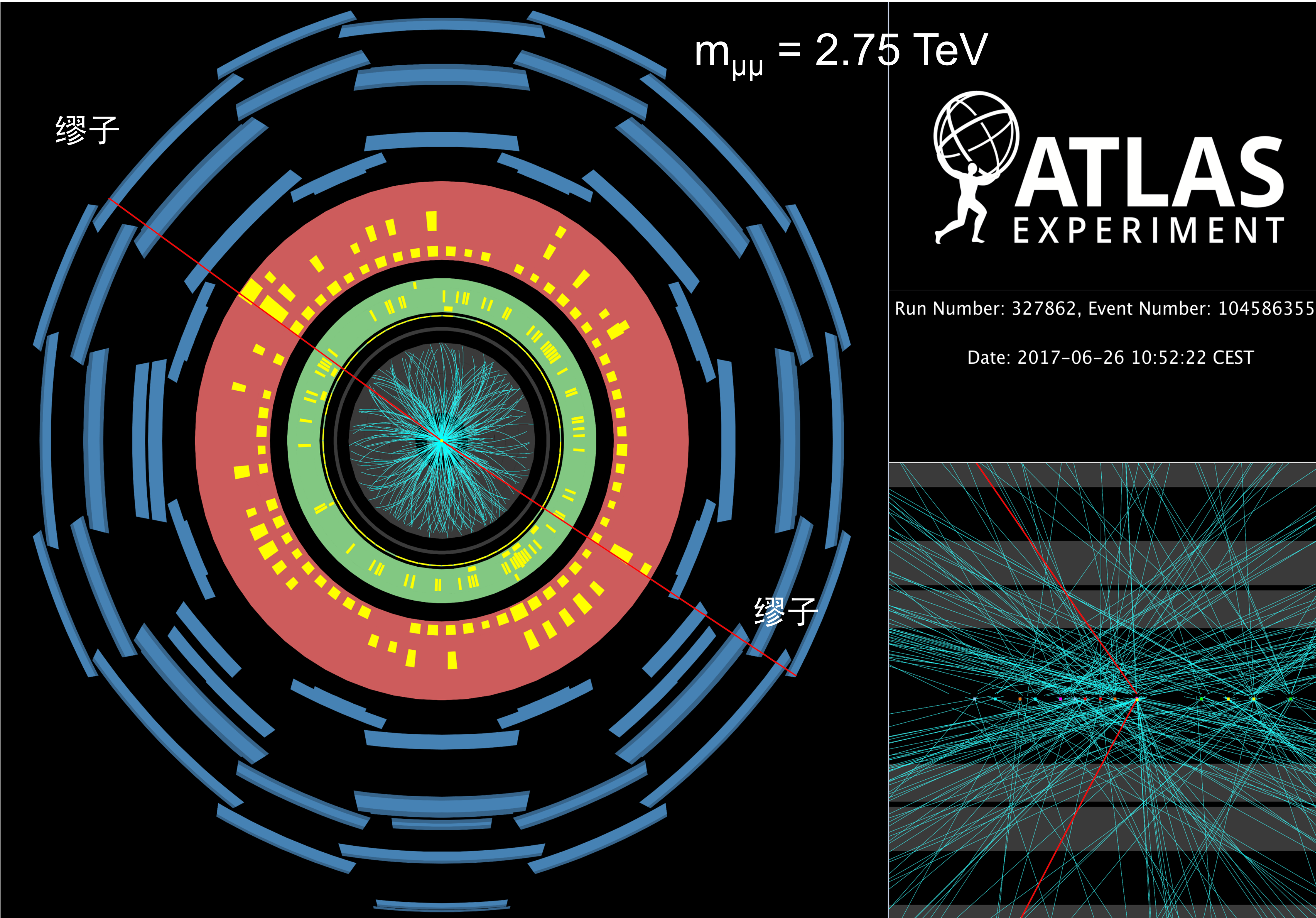
ATLAS-CONF-2019-007

13 TeV, 139 fb-1, Full Run2 Data





Excited quarks < 6.7 TeV are excluded at the 95% C.L.

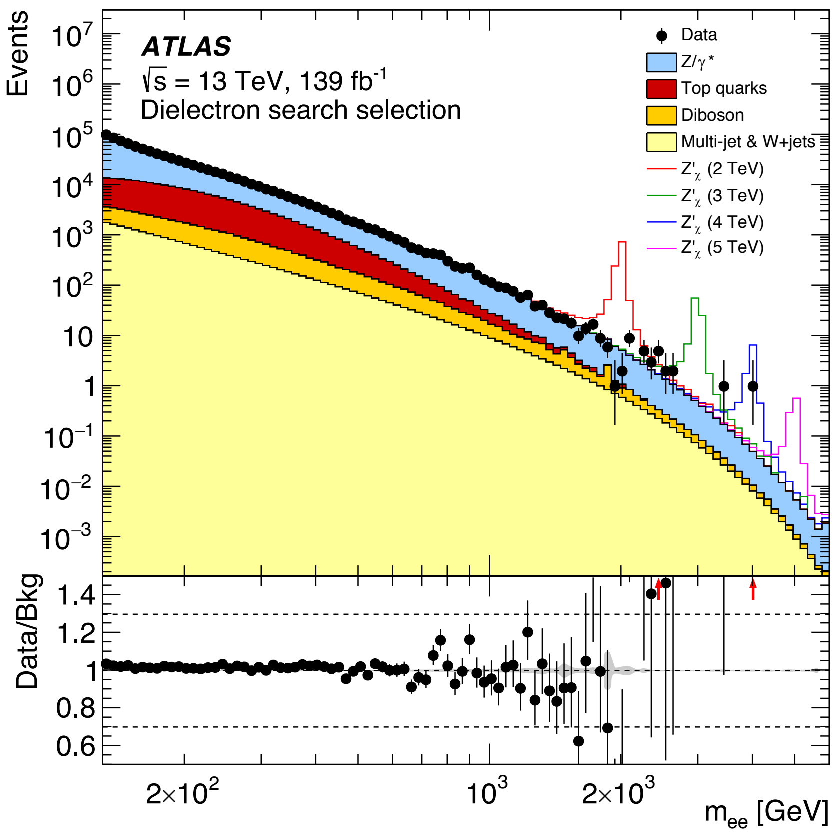

$m_{\mu\mu}$ = 2.75 TeV
缪子
缪子
ATLAS EXPERIMENT
Run Number: 327862, Event Number: 1045863550
Date: 2017-06-26 10:52:22 CEST

Z’→ee/$\mu\mu$

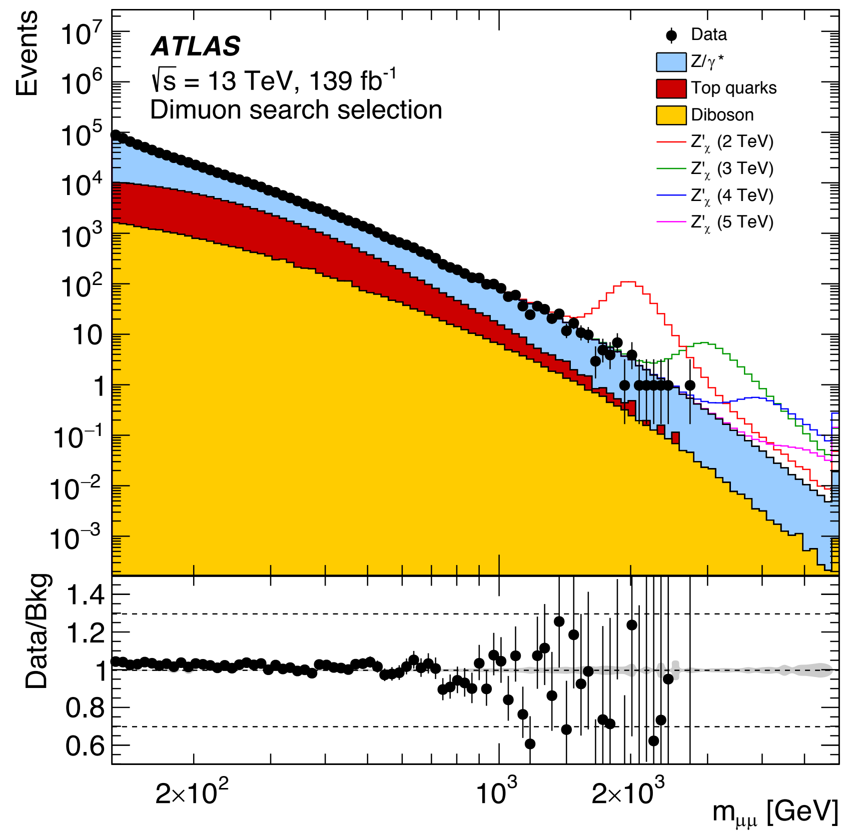
arXiv:1903.06248

13 TeV, 139 fb-1, Full Run2 Data

最大 m_{ee} = 4.06 TeV



最大$m_{\mu\mu}$ = 2.75 TeV

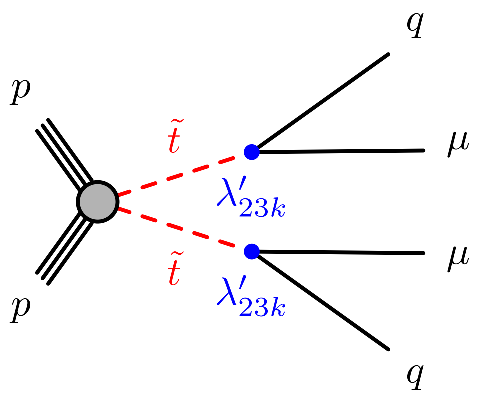


Sequential Standard Model Z'_{SSM} < 5.1 TeV are excluded at 95 % CL

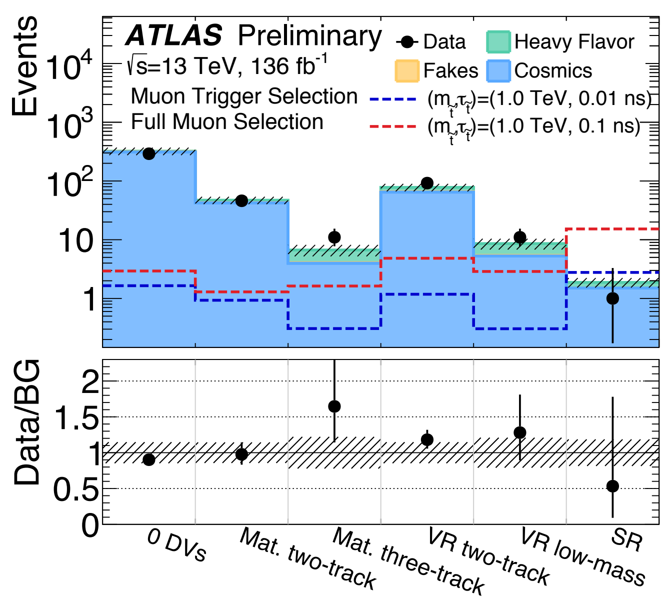
SUSY – stop - Long Lived Particles

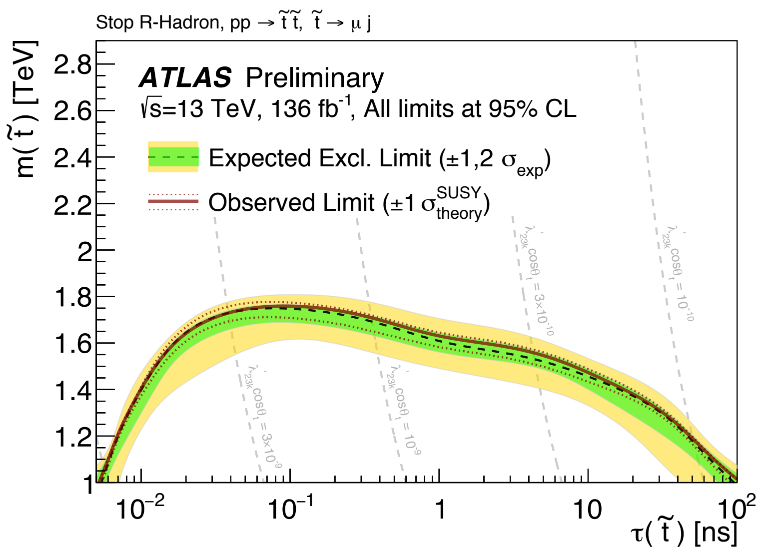
ATLAS-CONF-2019-006

13 TeV, 139 fb-1, Full Run2 Data



˜t 长寿命 → displaced vertex





- Top squarks with masses up to 1.7 TeV are excluded for a lifetime of 0.1 ns
- Masses below 1.3 TeV are excluded for all lifetimes between 0.01 ns and 30 ns

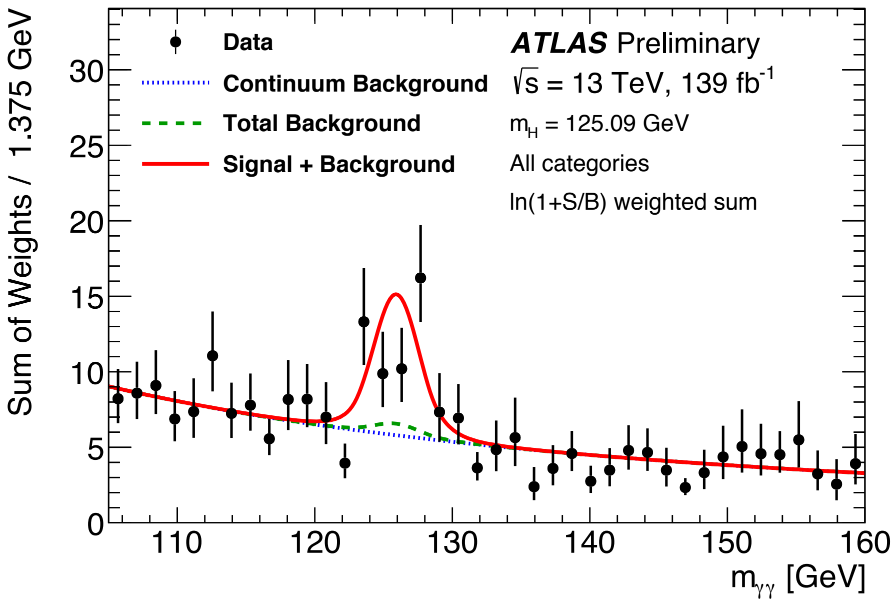
Higgs物理

ttH, H→$\gamma\gamma$

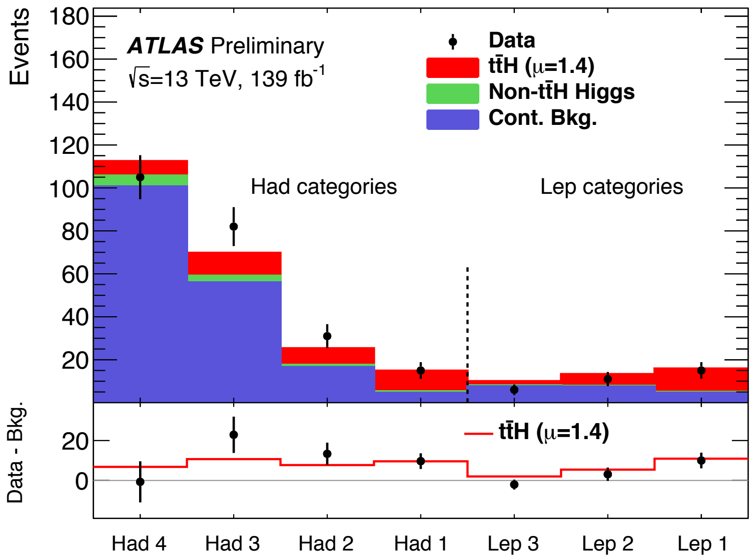
ATLAS-CONF-2019-004

13 TeV, 139 fb-1, Full Run2 Data

log(1+S/B) weighted



Event Yields



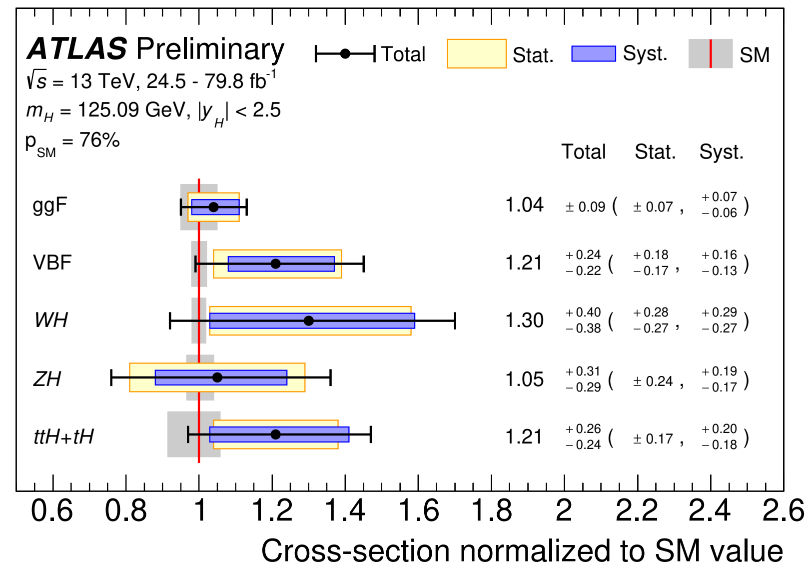
Obs. (exp.) significance: 4.9 (4.2) σ

$$\mu_{t\bar{t}H} = 1.38\,^{+0.41}_{-0.36} = 1.38\,^{+0.33}_{-0.31}\,(\text{stat.})\,^{+0.13}_{-0.11}\,(\text{exp.})\,^{+0.22}_{-0.14}\,(\text{theo.}).$$

Combined Measurements of Higgs

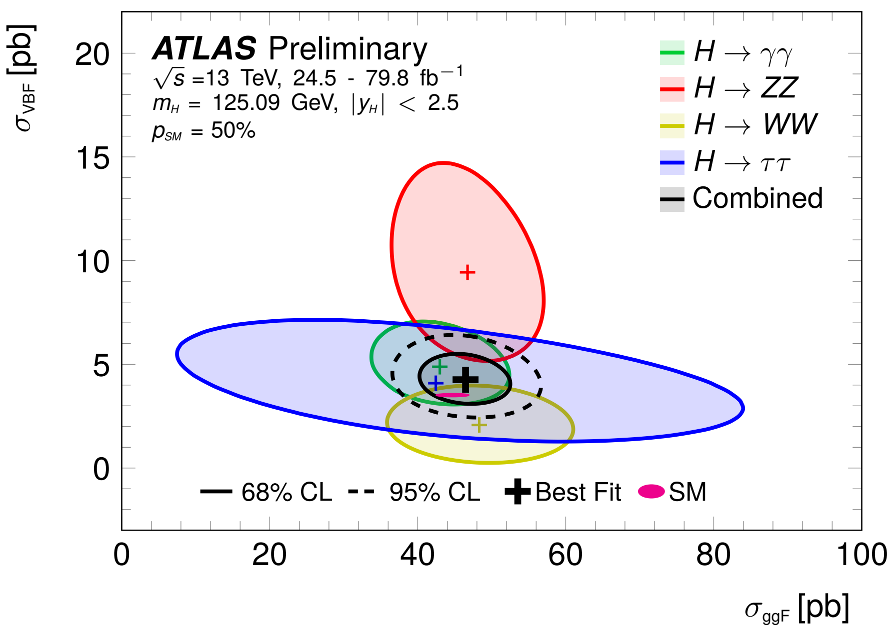
ATLAS-CONF-2019-005

Analysis	Integrated luminosity (fb^{-1})
$H \to \gamma\gamma$ (including $t\bar{t}H$, $H \to \gamma\gamma$)	79.8
$H \to ZZ^* \to 4\ell$ (including $t\bar{t}H$, $H \to ZZ^* \to 4\ell$)	79.8
$H \to WW^* \to e\nu\mu\nu$	36.1
$H \to \tau\tau$	36.1
VH, $H \to b\bar{b}$	79.8
VBF, $H \to b\bar{b}$	24.5 – 30.6
$H \to \mu\mu$	79.8
$t\bar{t}H$, $H \to b\bar{b}$ and $t\bar{t}H$ multilepton	36.1
$H \to$ invisible	36.1
Off-shell $H \to ZZ^* \to 4\ell$ and $H \to ZZ^* \to 2\ell 2\nu$	36.1



$$\mu = 1.11^{+0.09}_{-0.08} = 1.11 \pm 0.05\,(\text{stat.})\,^{+0.05}_{-0.04}\,(\text{exp.})\,^{+0.05}_{-0.04}\,(\text{sig. th.}) \pm 0.03\,(\text{bkg. th.})$$

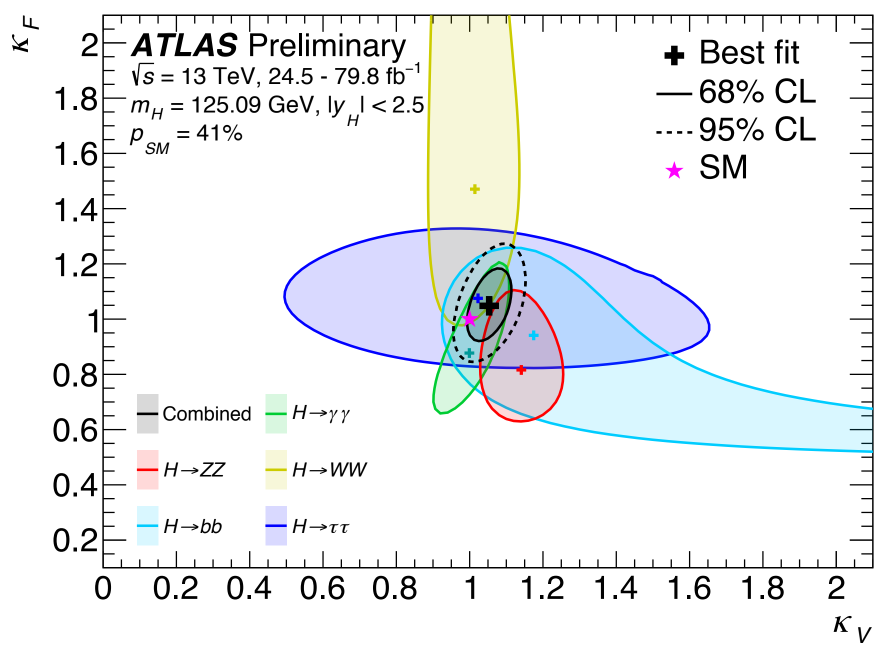
At same level



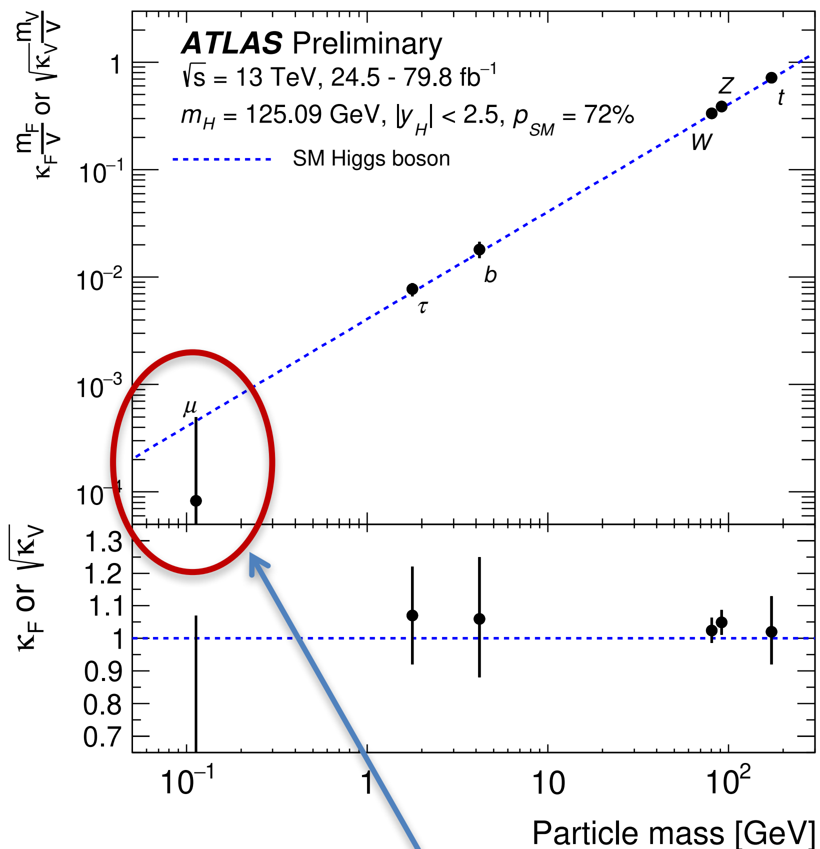
Combined Measurements of Higgs

ATLAS-CONF-2019-005

费米子



玻色子



$$\kappa_V = 1.05 \pm 0.04$$
$$\kappa_F = 1.05 \pm 0.09.$$

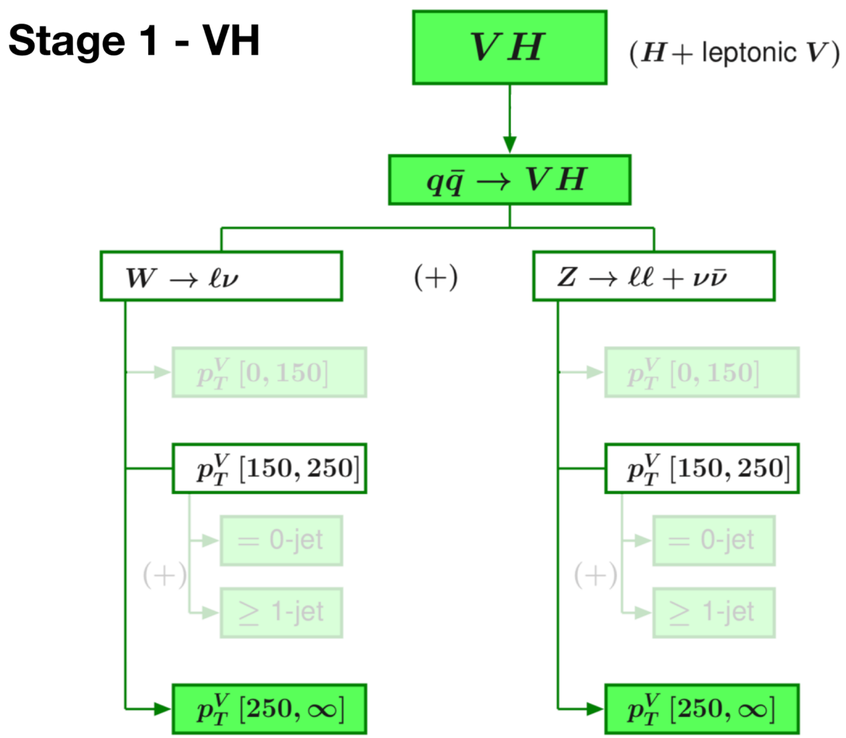
Consistent with SM

Next step

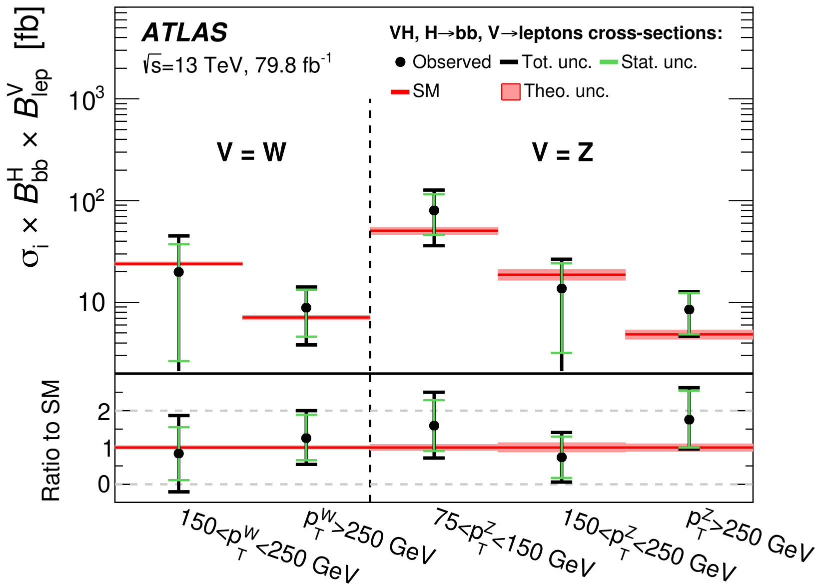
VH, H→bb: Simplified Template X.S.

13 TeV, 80 fb-1

arXiv:1903.04618



Sensitive to new physics



Simplified Template Cross Section (STXS)

- Define a set of phase spaces to be used for Higgs XS measurements.
- Reduce model dependence and increase sensitivity to new physics.
- Easy to combine different channels

Top物理

Spin Correlation

arXiv:1903.0757

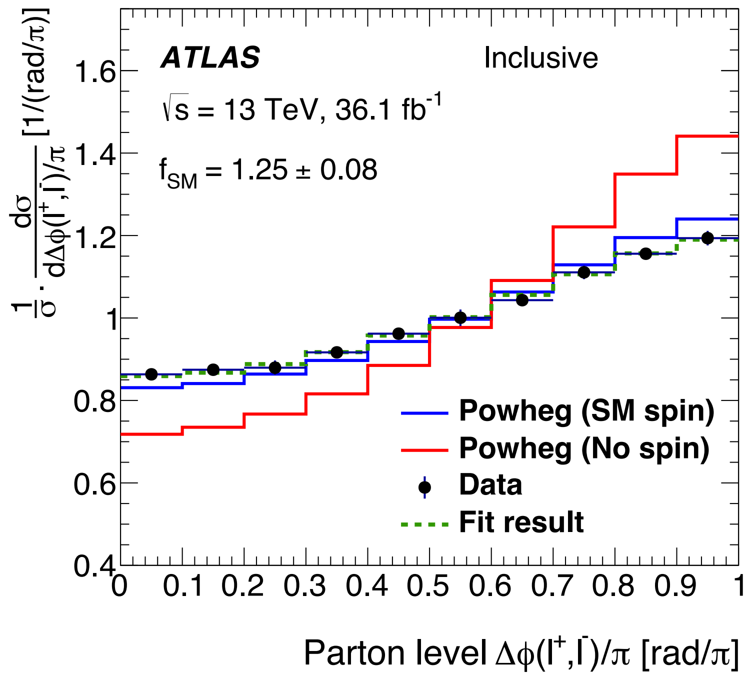
13 TeV, 36 fb-1

$$x_i = f_{\text{SM}} \cdot x_{\text{spin},\, i} + (1 - f_{\text{SM}}) \cdot x_{\text{nospin},\, i} \ ,$$

f_{SM}=1：符合标准模型

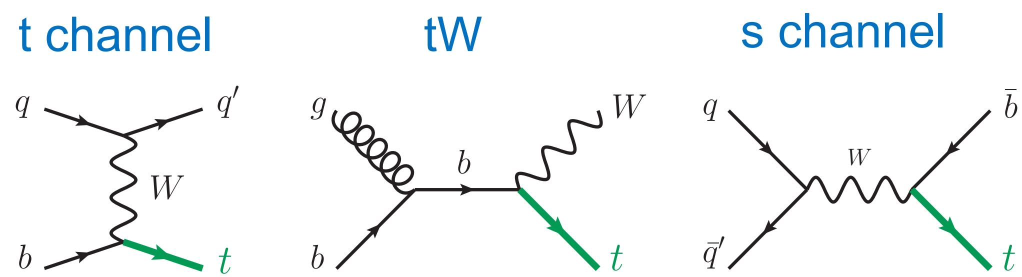
- Indirectly probe the spin correlations using Δφ in lab frame
- Enhancement at low Δφ and suppression at high Δφ

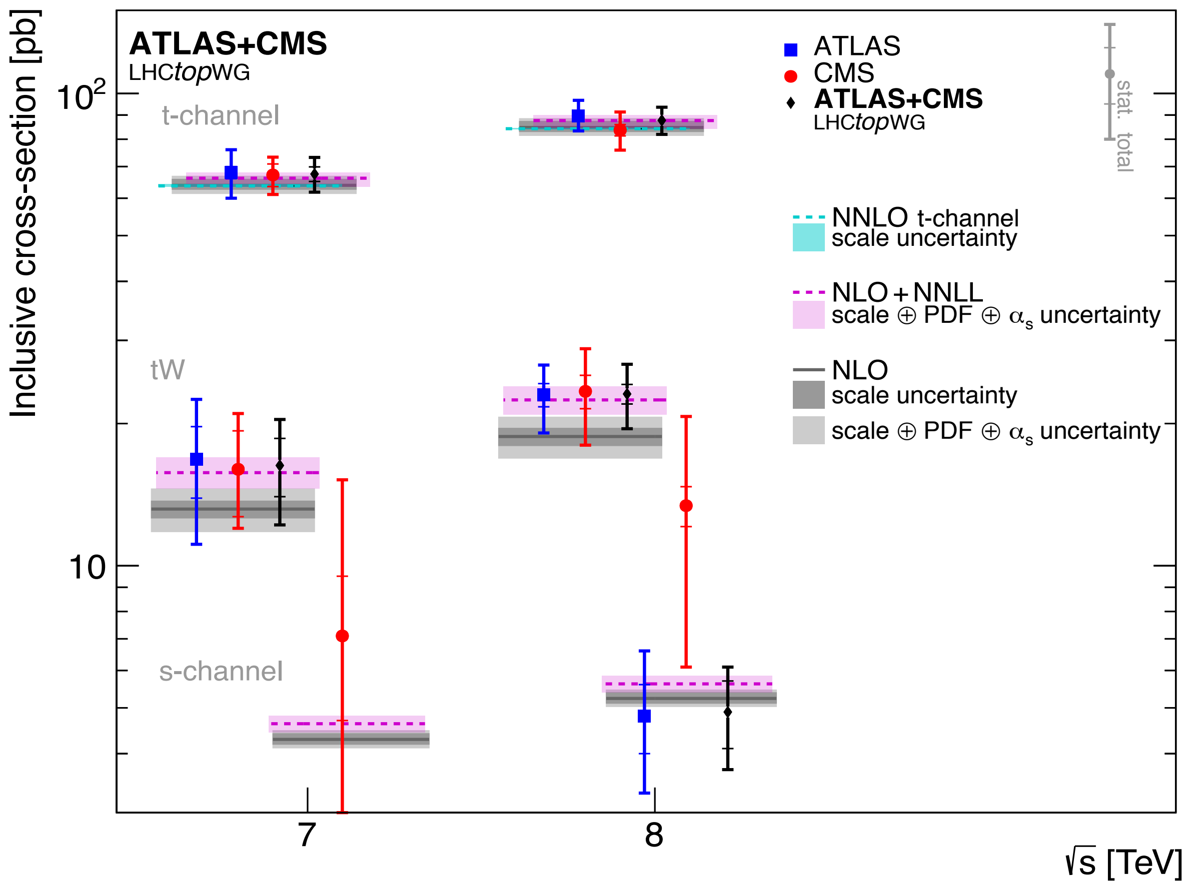
Region	f_{SM} ± (stat.,syst.,theory)	Significance (excl. theory uncertainties)
Inclusive	1.249 ± 0.024 ± 0.061 ± 0.040	3.2 (3.8)
$m_{t\bar{t}} < 450$ GeV	$1.12 \pm 0.04\ ^{+0.12}_{-0.13} \pm 0.02$	0.86 (0.87)
$450 \leq m_{t\bar{t}} < 550$ GeV	$1.18 \pm 0.08\ ^{+0.13}_{-0.14} \pm 0.08$	1.0 (1.1)
$550 \leq m_{t\bar{t}} < 800$ GeV	$1.65 \pm 0.19\ ^{+0.31}_{-0.41} \pm 0.22$	1.3 (1.4)
$m_{t\bar{t}} \geq 800$ GeV	$2.2 \pm 0.9\ ^{+2.5}_{-1.7} \pm 0.7$	0.58 (0.61)



Single Top: ATLAS+CMS Combination

LHC一期数据
7TeV和8 TeV

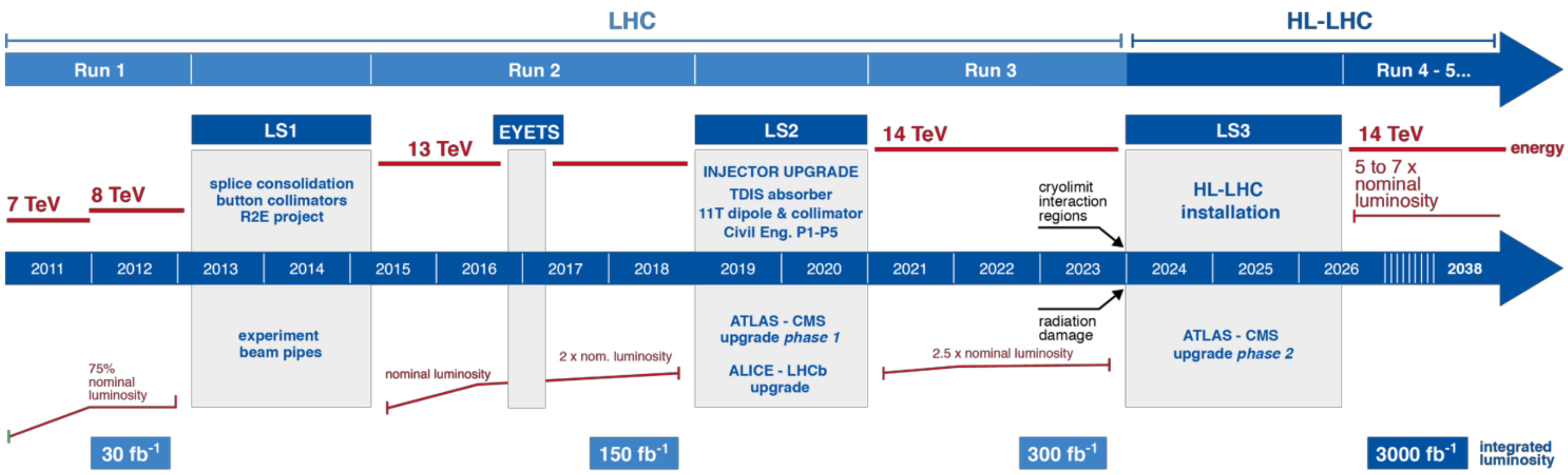




截面测量

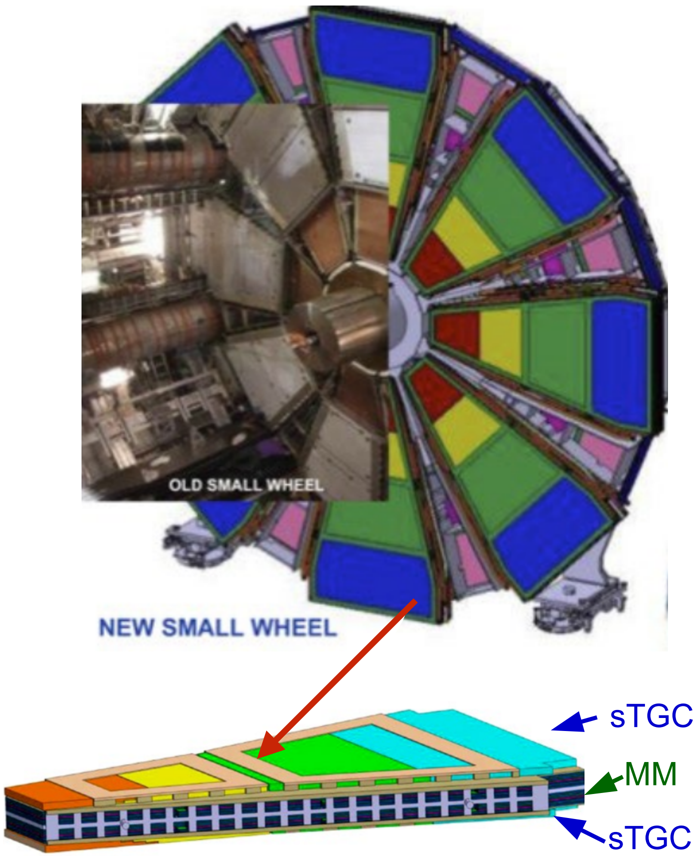
ATLAS探测器升级

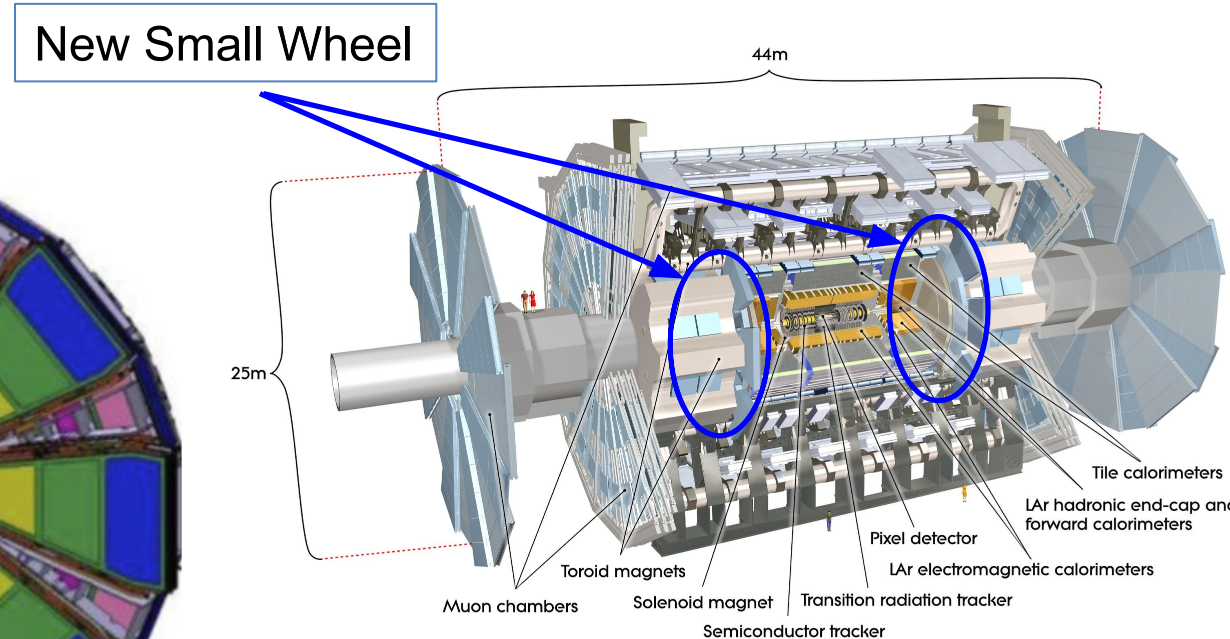
LHC计划



- Long Shutdown 2019-2020: ATLAS Phase-I Upgrade
- 2021-2023: LHC Run 3。 积累150 fb-1。Run 1 + Run 2 > 300 fb-1
- Run 3 LHC expectations: 瞬时亮度 L = $3 \times 10^{34} cm^{-2} s^{-1}$ at $\sqrt{s}$ = 14 TeV. →更大的pileup
- 需要提高触发判选的能力（效率和fake rejection）

Phase-I Upgrade - Muon





New Small Wheel (NSW)

- MicroMegas
- Thin Gap Chambers (sTGC)

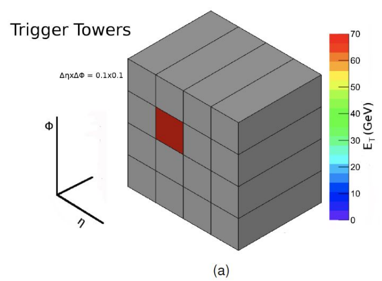
将提供

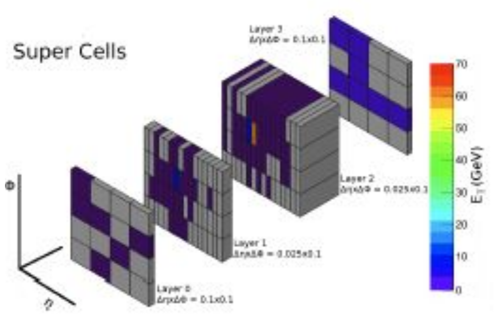
- 更精确的径迹
- 高颗粒度；更短的响应时间

Phase-I Upgrade

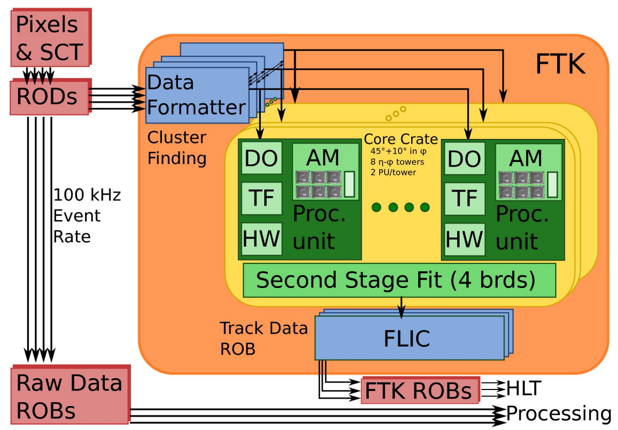
L1 Calo Trigger

- Better electronics
- More segmentation



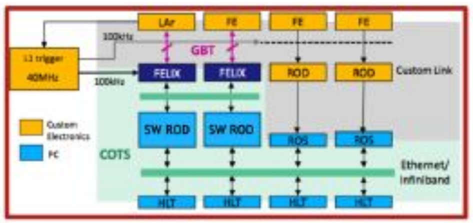


Fast Track Trigger



Tracking at Level 1 trigger rate (100 KHz)

Trigger and Data Acquisition

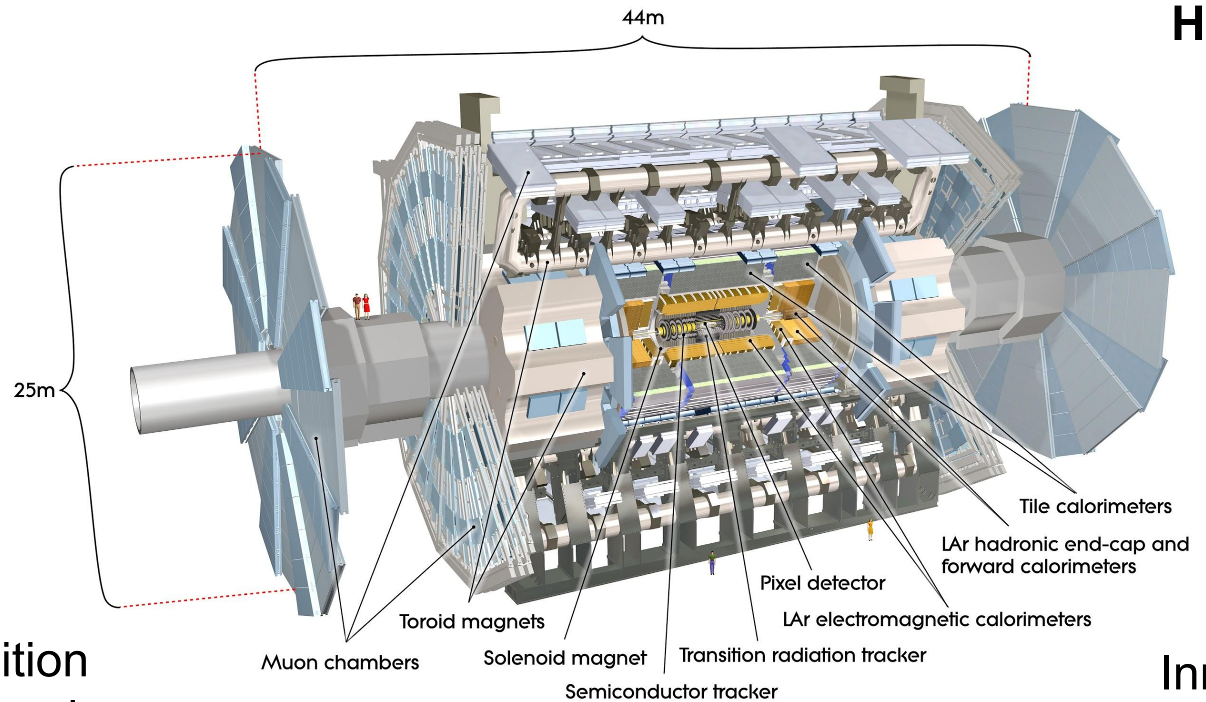


- FELIX unified readout interface electronics
- New trigger electronics and readouts needed for Muon and LAr Calorimeter

ATLAS Phase-II 升级计划

Muon Spectrometer Upgrade In Inner Barrel Region

High Granularity Timing Detector **HGTD**



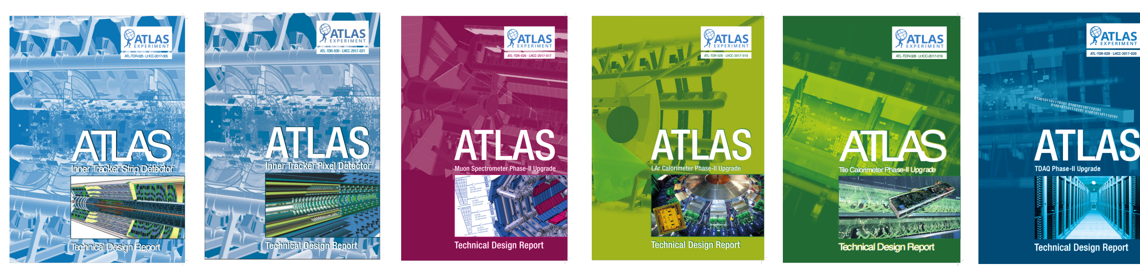
Trigger and Data Acquisition (TDAQ) Upgrades

Inner Tracking Detector **ITk**

总结

- ATLAS实验圆满完成了LHC二期的取数。各部分探测器工作正常。共获取149 fb^{-1}，效率>94%。可用做物理分析的积分亮度140 fb^{-1}
- 到目前为止，ATLAS一共提交文章840篇
- ATLAS持续探测新的领域，VVV的迹象，VBS的发现，Dijet，Z'的寻找，Long Lived Particles等等
- 精确测量Higgs（H to bb, ttH），top，标准模型其他过程(W质量，弱混合角)。Higgs领域的next challenge: $H\to\mu\mu$, $H\to Z\gamma$

积极准备Phase-I和Phase-II升级



Silicon Strip + Pixel tracker Muon system Calorimeters TDAQ

Backup

VVV

WWW 判选条件

	$WWW \to \ell\nu\ell\nu qq$	$WWW \to \ell\nu\ell\nu\ell\nu$
Lepton	Two leptons with $p_{\mathrm{T}} > 27(20)\,GeV$ and one same-sign lepton pair	Three leptons with $p_{\mathrm{T}} > 27(20,20)\,GeV$ and no same-flavour opposite-sign lepton pairs
$m_{\ell\ell}$	$40 < m_{\ell\ell} < 400$ GeV	–
Jets	At least two jets with $p_{\mathrm{T}} > 30(20)\,GeV$ and $\lvert\eta\rvert < 2.5$	–
m_{jj}	$m_{jj} < 300$ GeV	–
$\Delta\eta_{jj}$	$\lvert\Delta\eta_{jj}\rvert < 1.5$	–
$E_{\mathrm{T}}^{\mathrm{miss}}$	$E_{\mathrm{T}}^{\mathrm{miss}} > 55$ GeV (only for ee)	–
Z boson veto	$m_{ee} < 80$ GeV or $m_{ee} > 100$ GeV (only for ee and μee)	
Lepton veto	No additional lepton with $p_{\mathrm{T}} > 7$ GeV and $\lvert\eta\rvert < 2.5$	
b-jet veto	No b-jets with $p_{\mathrm{T}} > 25$ GeV and $\lvert\eta\rvert < 2.5$	

BDT 3l

Input Variable	3ℓ-1j	3ℓ-2j	3ℓ-3j
$m_{3\ell}$	5	4	5
$m_{\ell_0\ell_1}$	7	9	
$m_{\ell_0\ell_2}$	8	8	
$m_{\ell_1\ell_2}$	10	10	
leading jet p_{T}	12	14	
$p_{\mathrm{T}}^{\ell_0}$	3	3	
$p_{\mathrm{T}}^{\ell_1}$	6	5	8
$p_{\mathrm{T}}^{\ell_2}$	9	12	9
$E_{\mathrm{T}}^{\mathrm{miss}}$		6	11
$\Sigma p_{\mathrm{T}}(\ell)$	2	2	4
$\Sigma p_{\mathrm{T}}(j)$			2
H_{T}	4	7	
total lepton charge	13	15	12
invariant mass of all leptons, jets and $E_{\mathrm{T}}^{\mathrm{miss}}$	1		7
invariant mass of the best $Z \to \ell\ell$ and leading jet	11		
sub-leading jet p_{T}		11	3
m_{jj} for the two leading p_{T} jets		1	
$m_{\mathrm{T}}^{W\to\ell\nu}$		13	
number of reconstructed jets			10
$m_{jj}^{\text{best } W}$			1
smallest m_{jj}			6

BDT 4l

Input Variable	DF	on-shell SF	off-shell SF
number of reconstructed jets	6	4	6
$m_{4\ell}$	3	6	4
$E_{\mathrm{T}}^{\mathrm{miss}}$	4	1	1
$H_{\mathrm{T}}^{\mathrm{lep}}$	1		
$H_{\mathrm{T}}^{\mathrm{had}}$	5		
$m_{\ell\ell}^{\text{second best pair}}$	2	3	2
$m_{\ell\ell}^{\text{best } Z}$		5	5
H_{T}		2	3

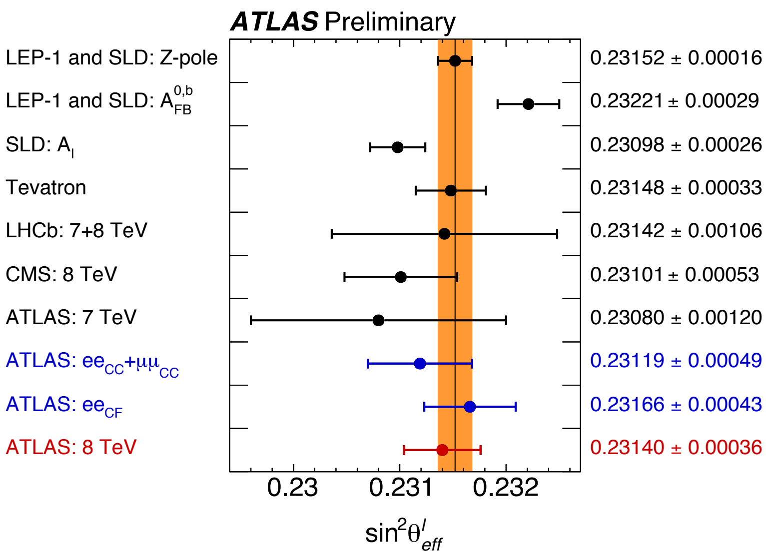
系统误差

Uncertainty source	$\Delta\mu$	
Data-driven	+0.14	–0.15
Theory	+0.15	–0.13
Instrumental	+0.11	–0.09
MC stat. uncertainty	+0.05	–0.05
Generators	+0.04	–0.03
Total systematic uncertainty	+0.30	–0.27

SM精确测量

电弱耦合角测量

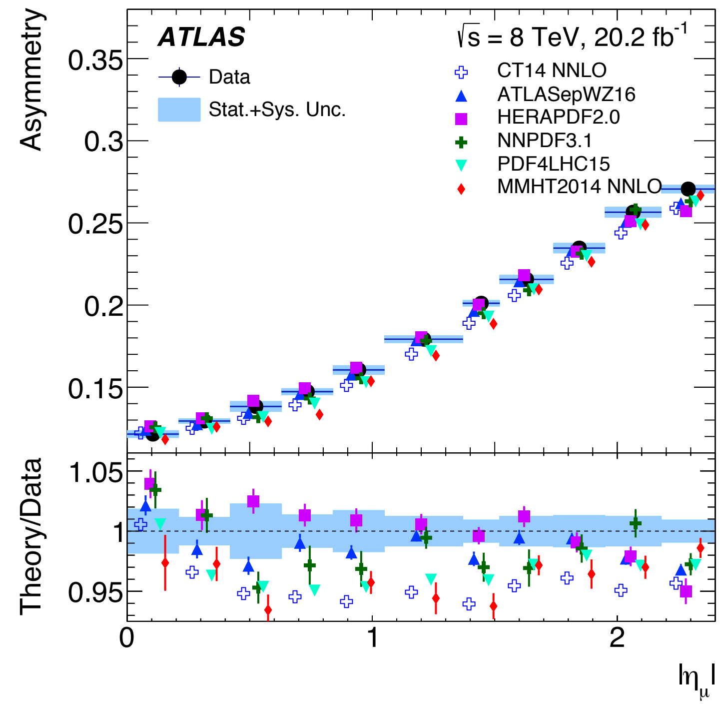
ATLAS-CONF-2018-037



W产生的电荷不对称性

PDF

arXiv:1904.05631



$$A_\mu = \frac{d\sigma_{W_\mu^+}/d\eta_\mu - d\sigma_{W_\mu^-}/d\eta_\mu}{d\sigma_{W_\mu^+}/d\eta_\mu + d\sigma_{W_\mu^-}/d\eta_\mu}\,.$$

8 TeV, 20 fb-1

WZ 极化

W:

$$\frac{1}{\sigma_{W^\pm Z}}\frac{d\sigma_{W^\pm Z}}{d\cos\theta_{\ell,W}} = \frac{3}{8}f_L[(1\mp\cos\theta_{\ell,W})^2] + \frac{3}{8}f_R[(1\pm\cos\theta_{\ell,W})^2] + \frac{3}{4}f_0\sin^2\theta_{\ell,W}\ ,$$

Z:

$$\begin{aligned}\frac{1}{\sigma_{W^\pm Z}}\frac{d\sigma_{W^\pm Z}}{d\cos\theta_{\ell,Z}} &= \frac{3}{8}f_L(1+2\alpha\cos\theta_{\ell,Z}+\cos^2\theta_{\ell,Z})\\ &+ \frac{3}{8}f_R(1+\cos^2\theta_{\ell,Z}-2\alpha\cos\theta_{\ell,Z})\\ &+ \frac{3}{4}f_0\sin^2\theta_{\ell,Z}\ ,\end{aligned}$$

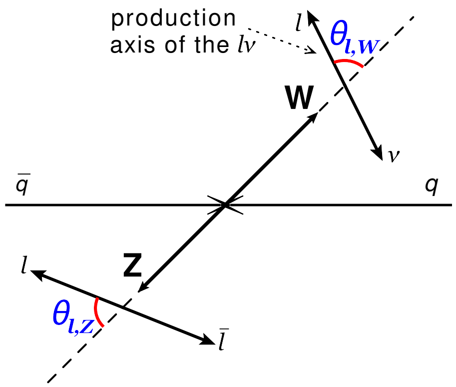
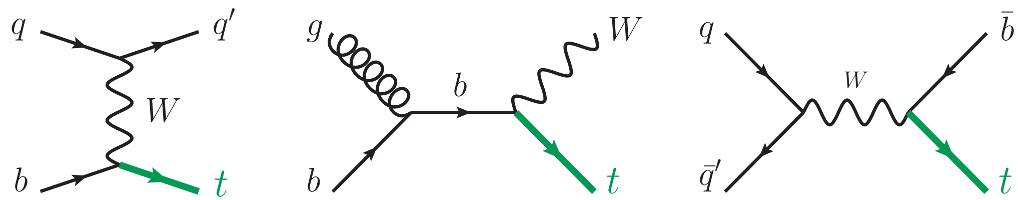


Figure 7: The decay angle $\theta_{\ell,W(Z)}$ is defined as the angle between the negatively (positively for W^+) charged lepton produced in the decay of the W (Z) boson as seen in the W (Z) rest frame and the direction of the W (Z) which is given in the WZ centre-of-mass frame.

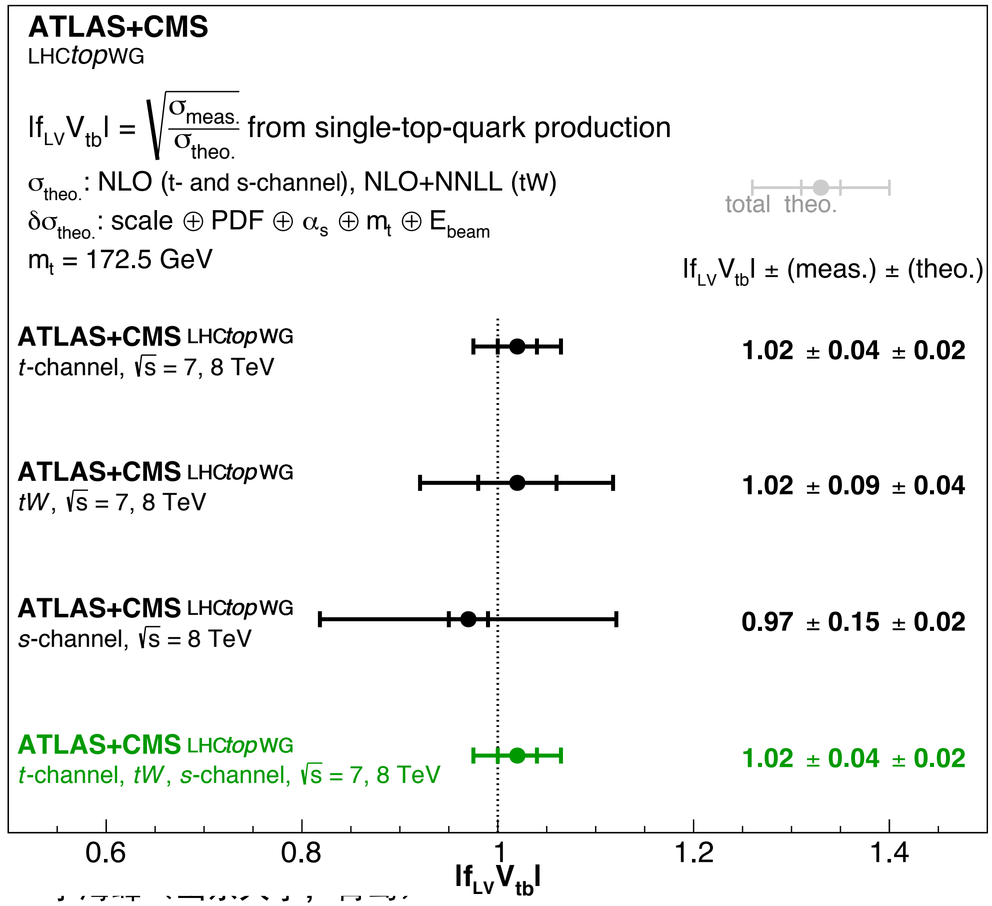
Single Top: ATLAS+CMS Combination

t channel　　tW　　s channel



LHC一期数据
7TeV和8 TeV

$$|f_{LV} V_{tb}| = \sqrt{\frac{\sigma_{meas.}}{\sigma_{theo.}(V_{tb}=1)}}$$

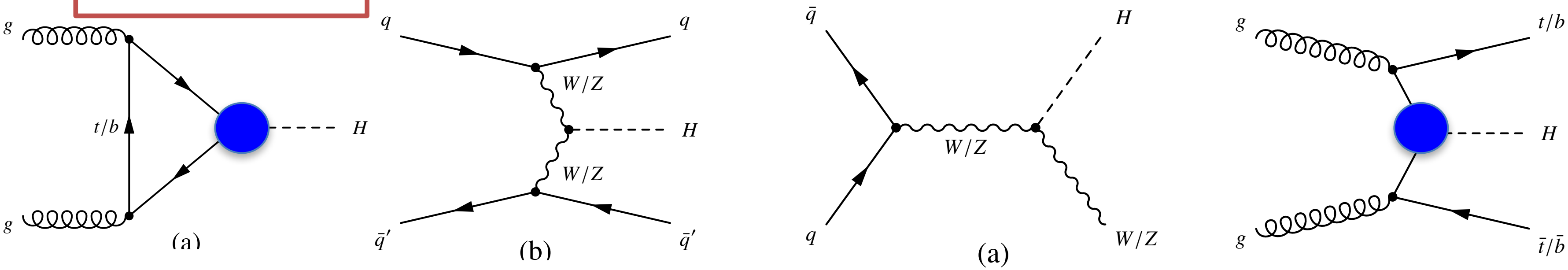


Higgs Coupling Measurement

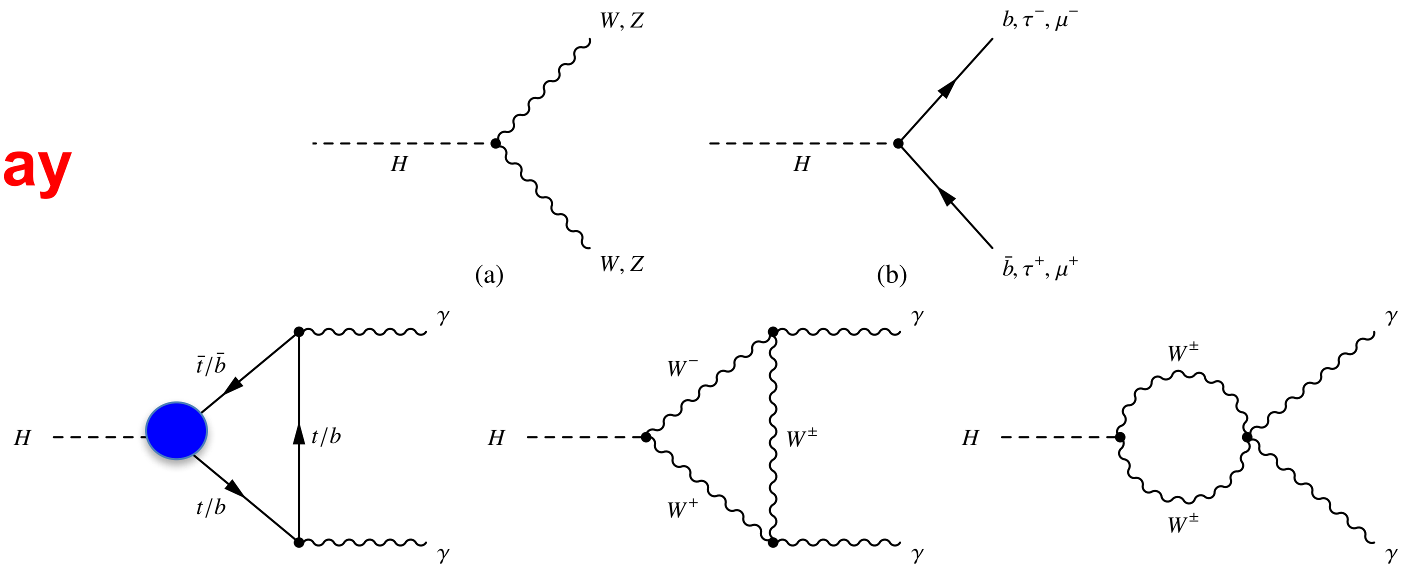
- Coupling information can be extracted from individual processes

ttH/bbH

production



decay

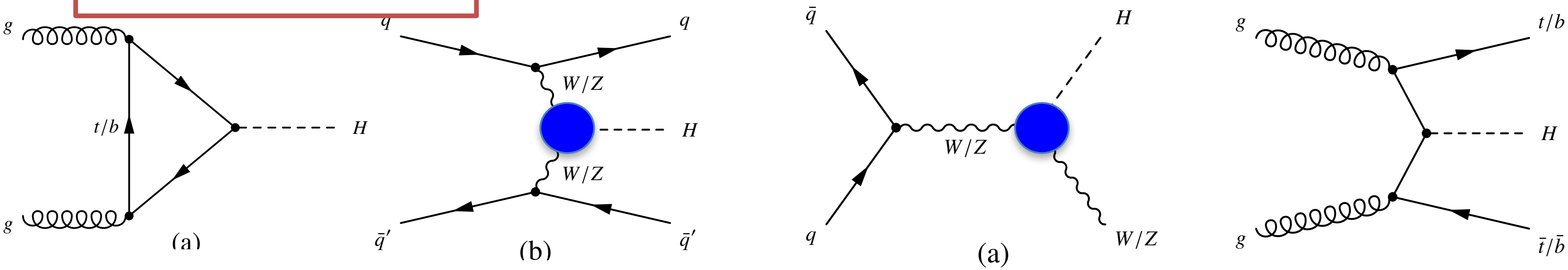


Higgs Coupling Measurement

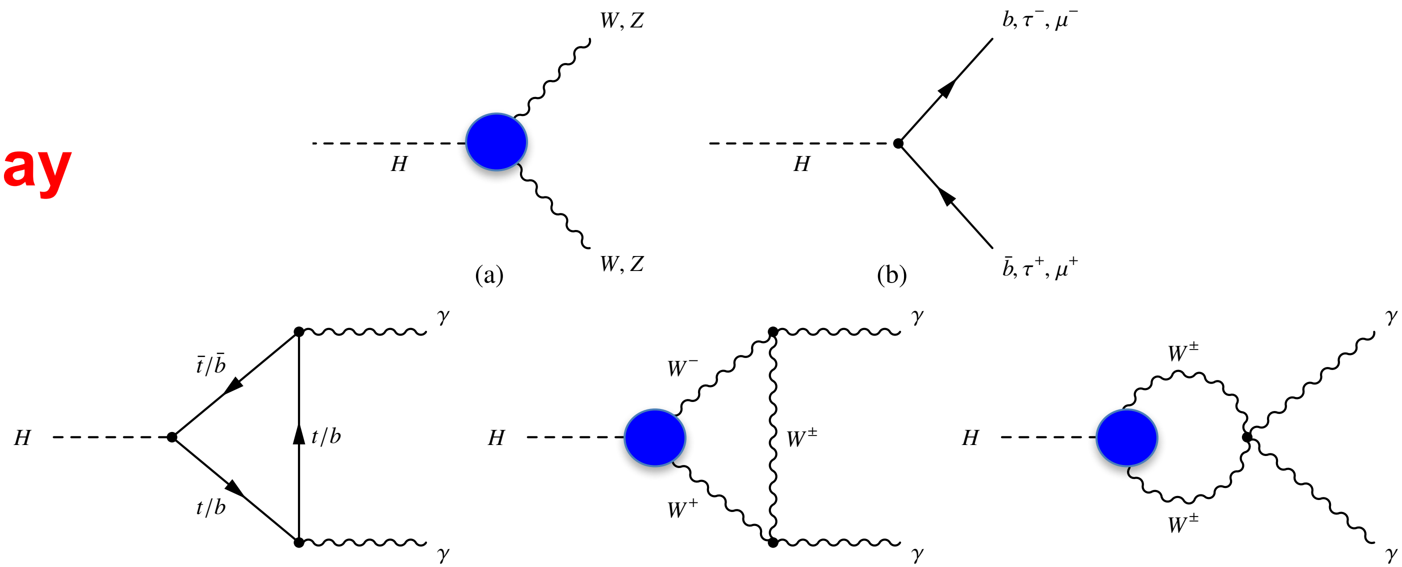
- Coupling information can be extracted from individual processes

WWH/ZZH

production



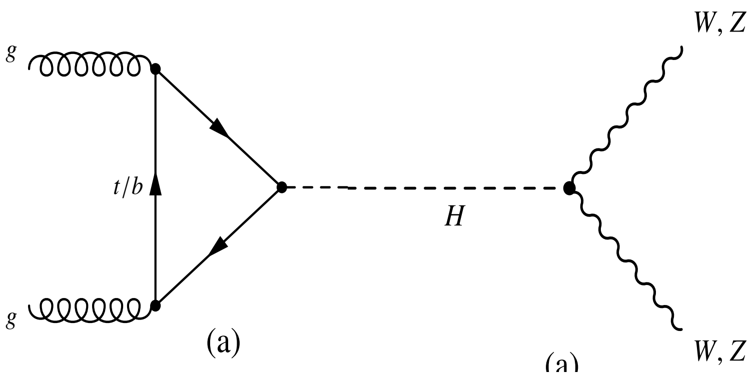
decay



Signal strength and fitting framework

$$\mu_i^f = \frac{\sigma_i \cdot \mathrm{BR}^f}{(\sigma_i)_{\mathrm{SM}} \cdot (\mathrm{BR}^f)_{\mathrm{SM}}} = \mu_i \times \mu^f$$

Leading-order motivated framework: κ-framework



$$\sigma_i \cdot \mathrm{BR}^f = \frac{\sigma_i(\vec{\kappa}) \cdot \Gamma^f(\vec{\kappa})}{\Gamma_{\mathrm{H}}},$$

Definition of modifier: $\kappa_j^2 = \sigma_j / \sigma_j^{\mathrm{SM}}$ or $\kappa_j^2 = \Gamma^j / \Gamma^j_{\mathrm{SM}}.$

Dictionary

Production	Loops	Interference	Effective modifier	Resolved modifier
σ(ggF)	✓	$t-b$	κ_g^2	$1.04\,\kappa_t^2 + 0.002\,\kappa_b^2 - 0.04\,\kappa_t\kappa_b$
σ(VBF)	-	-	-	$0.73\,\kappa_W^2 + 0.27\,\kappa_Z^2$
$\sigma(qq/qg \to ZH)$	-	-	-	κ_Z^2
$\sigma(gg \to ZH)$	✓	$t-Z$	$\kappa_{(ggZH)}$	$2.46\,\kappa_Z^2 + 0.46\,\kappa_t^2 - 1.90\,\kappa_Z\kappa_t$
$\sigma(WH)$	-	-	-	κ_W^2
$\sigma(t\bar{t}H)$	-	-	-	κ_t^2
$\sigma(tHW)$	-	$t-W$	-	$2.91\,\kappa_t^2 + 2.31\,\kappa_W^2 - 4.22\,\kappa_t\kappa_W$
$\sigma(tHq)$	-	$t-W$	-	$2.63\,\kappa_t^2 + 3.58\,\kappa_W^2 - 5.21\,\kappa_t\kappa_W$
$\sigma(b\bar{b}H)$	-	-	-	κ_b^2
Partial decay width				
Γ^{bb}	-	-	-	κ_b^2
Γ^{WW}	-	-	-	κ_W^2
Γ^{gg}	✓	$t-b$	κ_g^2	$1.11\,\kappa_t^2 + 0.01\,\kappa_b^2 - 0.12\,\kappa_t\kappa_b$
$\Gamma^{\tau\tau}$	-	-	-	κ_τ^2
Γ^{ZZ}	-	-	-	κ_Z^2
Γ^{cc}	-	-	-	$\kappa_c^2\ (=\kappa_t^2)$
$\Gamma^{\gamma\gamma}$	✓	$t-W$	κ_γ^2	$1.59\,\kappa_W^2 + 0.07\,\kappa_t^2 - 0.67\,\kappa_W\kappa_t$
$\Gamma^{Z\gamma}$	✓	$t-W$	$\kappa_{(Z\gamma)}^2$	$1.12\,\kappa_W^2 - 0.12\,\kappa_W\kappa_t$
Γ^{ss}	-	-	-	$\kappa_s^2\ (=\kappa_b^2)$
$\Gamma^{\mu\mu}$	-	-	-	κ_μ^2
Total width ($B_{inv} = B_{undet} = 0$)				
Γ_H	✓	-	κ_H^2	$0.58\,\kappa_b^2 + 0.22\,\kappa_W^2$ $+0.08\,\kappa_g^2 + 0.06\,\kappa_\tau^2$ $+0.03\,\kappa_Z^2 + 0.03\,\kappa_c^2$ $+0.0023\,\kappa_\gamma^2 + 0.0015\,\kappa_{(Z\gamma)}^2$ $+0.0004\,\kappa_s^2 + 0.00022\,\kappa_\mu^2$

Profile likelihood and systematics

Nuisance parameters: about 4200 NPs (most of them are related to MC statistics uncertainties), one single fitting takes hours

$$\Lambda(\vec{\alpha}) = \frac{L(\vec{\alpha}, \hat{\hat{\vec{\theta}}}(\vec{\alpha}))}{L(\hat{\vec{\alpha}}, \hat{\vec{\theta}})}$$

POI

- RooFit development
- Asymptotic method

- Most of experimental systematics are assumed uncorrelated
- Main correlated systematics are the signal theoretical uncertainties